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Parasites of the Oriental Fruit Moth in Virginia

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For a number of years a project has been in operation providing for the liberation of parasites of the oriental fruit moth, *Grapholitha molesta* (Busch), by the U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine in cooperation with the Virginia Agricultural Experiment Station. A number of species of parasites have been liberated and recovery studies have been made.

This paper is a report on collections of larval parasites made independently of the above cooperative project. A brief note will be given, however, on the liberations made by the Bureau, since these liberations necessarily have a bearing on the results obtained in the work.

Liberations.—The parasite *Macrocentrus ancylivorus* Roh. was first liberated in this state in 1931. Since that date other liberations of this parasite have been made in 18 different localities.

Methods.—Peach twigs infested with oriental fruit moth larvae were collected at the following points in the state: Rockingham County, in one orchard at Broadway and three at Timberville; Albemarle County, in four orchards at Crozet, two at Greenwood, one at Batesville and one at Afton; Augusta County, in two orchards at Waynesboro and one at Staunton; Nelson County, in one orchard at Lovingston and one near Covesville; Amherst County, in two orchards at Elon and one at Monroe; and Botetourt County, in one orchard. From 1935 to 1938, inclusive, collections were made in Albemarle County during the first, second and third broods of the oriental fruit moth. There were no collections made, however, during the third brood in 1937 and 1938 because of the hardening of the twigs.

The twigs were put in battery jars, and apples were added to furnish food for larvae that could not complete their growth in the twigs. Strips of corrugated paper were also added to provide cocooning quarters for the larvae when mature. Each morning the jars were examined and any moths and parasites present were removed. The following data were recorded for each parasite: Name of orchard in which collected; locality; date of collection of twigs; and date of emergence. Specimens of the parasites were submitted to the Division of Insect Identification, Bureau of Entomology and Plant Quarantine, for identification. The percentages of parasitism given in this paper were calculated from the number of moths and parasites reared to maturity, the individuals dying in immature stages not being considered in the calculations.

Results.—Ten species of parasites were reared from the fruit moth larvae collected, table 1. The total parasitism by all species was 47.44 per cent. Recoveries were made of one of the liberated species of parasites, *Macrocentrus ancylivorus*. Of the parasites reared, only two species, *M. ancylivorus* and *Glypta rufiscutellaris* Cress. were sufficiently numerous to have been of value in the control of the fruit moth. Discussions of these two species and also of *M. delicatus* Cress. are given below. A single individual identified as *Ascogaster quadridentatus* Wesm. was reared. This is the name now applied to the species which was previously known in the United States as *Ascogaster carpocapsae* (Vier.) and which is a common parasite of the codling moth in Virginia.

Macrocentrus ancylivorus.—This parasite has been by far the most abundant species reared. In the seasons 1937 and 1938, it has represented 78.44 per cent of all the parasites reared and has accounted for an average of 37.21 per cent parasitism of fruit moth larvae. In Albe-

* The writer wishes to acknowledge his indebtedness to the following men for identifications: R. A. Cushman, identification of *Glypta rufiscutellaris* Cress., *Pristomerus ocellatus* Cushm., *Dioctes obliteratus* (Cress.), *Cremastus minor* Cushm. and *Cremastus grapholithae* Cushm.: and C. F. W. Muesebeck, identification of *Macrocentrus ancylivorus* Roh., *Macrocentrus instabilis* Mues. and *Eubadizon pleurale* Cress.

marle County, where it was first liberated in 1931, there was a parasitism of 60.82 and 60.16 per cent in 1937 and 1938, respectively. In Rockingham and Augusta counties, where it had also been liberated as early as 1931, however, a parasitism of only 0.15 and 0.61 per cent, respectively, in 1938, was found. The parasite was liberated in small numbers in Nelson County

MACROCENTRUS DELICATUS.—In these studies *Macrocentrus delicatus* has been of little value as a parasite of the oriental fruit moth. Only 1.77 per cent of the parasites reared in 1937 and 1938 were of this species, and it accounted for a parasitism of only 0.85 per cent of the larvae collected. In Albermarle County the parasite has been reared in large numbers from the

Table 1.—Moths and parasites reared from oriental fruit moth larvae collected in peach twigs in 1937 and 1938.

Items	Counties From Which Twigs Were Collected										Total	
	Rockingham	Albemarle		Augusta	Nelson		Amherst		Botetourt			
	1938	1937	1938	1938	1937	1938	1937	1938	1937	1938	1937	1938
Moths Number	454	75	243	231	55	14	73	261	168	111	371	1,314
Parasites* *Macrocentrus ancylivorus* Roh. Number	1	118	373	2	2	116	—	—	23	558	143	1,050
Per cent parasitism	0.15	60.82	60.16	0.61	3.45	84.67	—	—	11.11	82.79	26.88	39.27
Macrocentrus delicatus Cress. Number	1	—	—	4	—	—	—	6	16	—	16	11
Per cent parasitism	0.15	—	—	1.23	—	—	—	2.21	7.73	—	3.01	0.41
Glypta rufiscutellaris Cress. Number	185	—	2	86	—	2	—	4	—	—	0	279
Per cent parasitism	28.64	—	0.32	26.46	—	1.46	—	1.47	—	—	0.0	10.43
Macrocentrus instabilis Mues. Number	—	—	—	—	—	—	—	1	—	—	0	1
Pristomerus ocellatus Cushm. Number	1	—	—	2	—	—	—	—	—	—	0	3
Eubadizon pleurale Cress. Number	2	—	—	—	—	—	—	—	—	—	0	2
Cremastus minor Cushm. Number	—	—	2	—	—	—	—	—	—	5	0	7
Cremastus graptolithae Cushm. Number	—	—	—	—	1	5	—	—	—	—	1	5
Dicetes obliteratus (Cress.) Number	2	—	—	—	—	—	—	—	—	—	0	2
Aswogaster quadridentatus Wesm. Number	—	1	—	—	—	—	—	—	—	—	1	0

* The percentages of parasitism are given in the table only for the first three species, since the other species are represented merely by a few scattered individuals. These percentages are based upon the number of moths and parasites that emerged from the material collected.

in June, 1936, and there followed a parasitism of 3.45 per cent in 1937 and 84.67 per cent in 1938. In Botetourt County, where liberations were also made in 1936, parasitism was 11.11 per cent in 1937 and 82.79 per cent in 1938.

It is apparent that a high percentage of larval parasitism is necessary during the first two broods of the oriental fruit moth in order to be of value in reducing fruit infestation during the third brood. Table 2 gives the parasitism of first, second and third brood larvae, all or in part, by *Macrocentrus ancylivorus* in the years 1935 to 1938, inclusive. As may be noted, a parasitism of 94.60 per cent was reached during the second brood in 1938.

ragweed borer during the past 4 years, but not an individual has been reared from fruit moth larvae. In Botetourt County, 41.03 per cent of all the parasites reared in 1937 were *M. delicatus*, but none of this species were reared in 1938. In Amherst County, *M. delicatus* was the predominating species in 1938, although it was responsible for a parasitism of only 2.21 per cent of the larvae that were collected in that year.

GLYPTA RUFISCUTELLARIS.—In the number of individuals reared, *Glypta rufiscutellaris* ranks next to *Macrocentrus ancylivorus*. It may be seen in table 1, however, that parasitism by this insect was somewhat irregular. The material collect-

ed in Rockingham and Augusta counties showed a parasitism of 28.64 and 26.46 per cent, respectively, in 1938, whereas few individuals were reared from collections made elsewhere. The parasite was responsible for a parasitism of 8.70 per cent of all the larvae collected and represented 18.34 per cent of all the parasites reared in these experiments.

ALL OTHER SPECIES.—Only occasional individuals of parasites other than the species given above were reared, table 1. A combined parasitism of only 0.69 per cent was found for the seven species included here.

Table 2.—The percentage of parasitism of oriental fruit moth larvae by *Macrocentrus ancylivorus* Roh. in Albemarle County, 1935-1938.

YEAR	BROOD OF LARVAE	NUMBER OF ORCHARDS COLLECTED	AVERAGE PER CENT OF PARASITISM*
1935	Second	3	46.22
	Third	4	51.60
1936	First	7	8.08
	Second	1	14.29
	Third	1	87.50
1937	First	1	22.22
	Second	2	68.45
1938	First	5	50.42
	Second	3	94.60
Average	First	4.3	26.91
	Second	2.3	55.89
	Third	2.5	69.55

* Based upon the number of moths and parasites that emerged from the material collected.

PROPORTION OF SEXES.—With each species of parasites reared in 1938, the females greatly outnumbered the males, table 3. The proportion of sexes for all the species combined was approximately three-fourths females, one-fourth males.

Table 3.—Percentage of male and female parasites reared from oriental fruit moth larvae in 1938.

SPECIES	NUMBER OF INDIVIDUALS	SEX	
		Females (Per Cent)	Males (Per Cent)
Macrocentrus ancylivorus Roh.	1050	76.10	23.90
Macrocentrus delicatus Cress.	10	80.00	20.00
Glypta rufiscutellaris Cress.	279	64.16	35.84
All others	20	80.00	20.00
Total or average	1259	75.06	24.94

SUMMARY.—Ten species of parasites were reared from oriental fruit moth larvae collected in Virginia in 1937 and 1938. *Macrocentrus ancylivorus* was, by far, the most important parasite, 78.44 per cent of all the individuals reared being of this species. It was responsible for a parasitism of 37.21 per cent of the larvæ collected, and in 1938 a parasitism of second brood larvae of 94.60 per cent by *M. ancylivorus* was found. Parasitism by *Glypta rufiscutellaris* was high in some orchards but low in others. In these studies, 18.34 per cent of all the parasites reared were of this species. The proportion of sexes for the parasites of all species reared in 1938 was approximately three-fourths females, one-fourth males. —6-29-39.

Insecticides for June Beetle Control*

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Few references to the use of insecticides for the control of adult June beetles are to be found in the voluminous economic literature on *Phyllophaga*. Smith (1889) reported upon the use of London purple as a spray on fruit trees. Vickery & Wilson (1919) utilized lead arsenate both as a spray and as a dust in southwestern cotton fields. Fluke & Ritcher (1935) applied lead arsenate sprays to prevent defoliation of oak trees in Wisconsin. Travis & Decker (1933) demonstrated reasonably effective kills with calcium arsenate in cage tests.

The results obtained in those tests and the new data included in the present paper are in accord with those obtained in the leaf-sandwich type of experiments conducted by Travis (1936) and Andre & Pratt (1936).

MATERIALS.—The beetles, *Phyllophaga implicita* (Horn), used in all these experiments were collected from American elm and willow trees. They were then confined in screened cages over moist soil and provided with foliage from the species of tree from which they had been taken.

All insecticides tested, except the sodi-

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† Resigned Sept. 1, 1935, to accept a position in the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture.

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um fluoride, which was a proprietary preparation, were diluted to contain two parts commercial insecticide to three parts bentonite by weight.

METHODS.—Except in series V of the tests, fresh elm and willow leaves were sprayed with a mist of water to simulate leaves dampened by fog or dew. This foliage was then dusted with an insecticide and placed in the beetle cages.

Duplicate series of 50 female beetles were used in each test; one received poisoned foliage only one night, the other two nights in succession. The number of males available was not sufficient to allow duplicate tests. Fresh untreated leaves were provided when dusted foliage was not in the cages. Four controls of 25 individuals each were used in each test; two received no food and two were given untreated food when the test series of beetles were offered dusted leaves.

In these experiments, the insecticides were used in three dosages which were rated by comparison with practical dusting of elm trees as: (1) light, 1–1½ pounds per tree; (2) moderate, 3 pounds; and (3) heavy, 4½ pounds.

The cages were kept in a screened insectary where the beetles were exposed to the normal outdoor temperature variations, and each day an examination was made to determine the number dead and alive. In view of the differences in their normal death rate and to a noticeable variation in their susceptibility to poisoning, the sexes were tested separately. Individuals that did not move their legs when gently pressed on the venter were considered dead.

Table 1.—Percentages of June beetles dead 144 hours after feeding on foliage dusted with various dosages of lead arsenate and calcium arsenate, 1933.

Dosage and Treatment	Dead Female Beetles							Dead Male Beetles			
	Series Number						Weighted Mean	Series Number			Weighted Mean
	I	II	III	IV	V	VI		I	II	III	
Lead Arsenate											
Light 1 night	86	32	80	80	76	86	74	88	16	92	65
Light 2 nights	94	84	90	92	84	94	90	96	60	92	83
Moderate 1 night	82	66	84	84	84	86	81	88	88	92	89
Moderate 2 nights	96	90	98	98	96	92	95	80	100	100	93
Heavy 1 night	86	92	92	98	90	76	88	84	96	92	91
Heavy 2 nights	98	100	100	100	92	100	98	100	88	100	96
Calcium Arsenate											
Light 1 night	16	10	10	46	12	14	18	52	8	20	27
Light 2 nights	74	28	90	76	20	26	52	96	12	84	64
Moderate 1 night	48	18	26	70	30	22	36	92	24	68	61
Moderate 2 nights	74	46	72	94	50	86	70	92	72	88	84
Heavy 1 night	84	30	32	80	24	56	51	88	28	84	67
Heavy 2 nights	94	80	84	96	68	80	84	92	48	100	80
Controls											
No food	10	0	6	28	8	16	11	28	32	64	41
Untreated food	4	6	22	34	8	18	15	20	20	48	29

Data on the length of time the beetles will feed upon poisoned foliage were obtained by confining individuals in 4-ounce stender dishes in a dimly lighted room, and watching carefully to see how long they fed upon leaves dusted with lead arsenate and calcium arsenate in the same proportions as were used in the cage tests.

LEAD ARSENATE.—This insecticide was tested on female beetles in six experiments and on males in three (see table 1). These tests, with the exception of II and V, were conducted under comparable conditions. In experiment II, beetles that were collected from willow ate sparingly of treated elm leaves which they were given by mis-

take, and this error in feeding evidently lowered the percentage of mortality. Although *Phyllophaga implicita* was collected on both willow and elm, those individuals taken on willow did not feed freely on elm leaves and vice versa.

It should be noted that very little of the poisoned foliage was consumed by the beetles in any of these tests. Much of the poison was shaken from the leaves by the activity of the beetles immediately following the emergence. This is particularly reflected in the reduced kill in experiment V, in which the leaves were dusted dry. Lead arsenate was so toxic that the differences in mortality resulting from the various applications of the poison were not large, fig. 1.

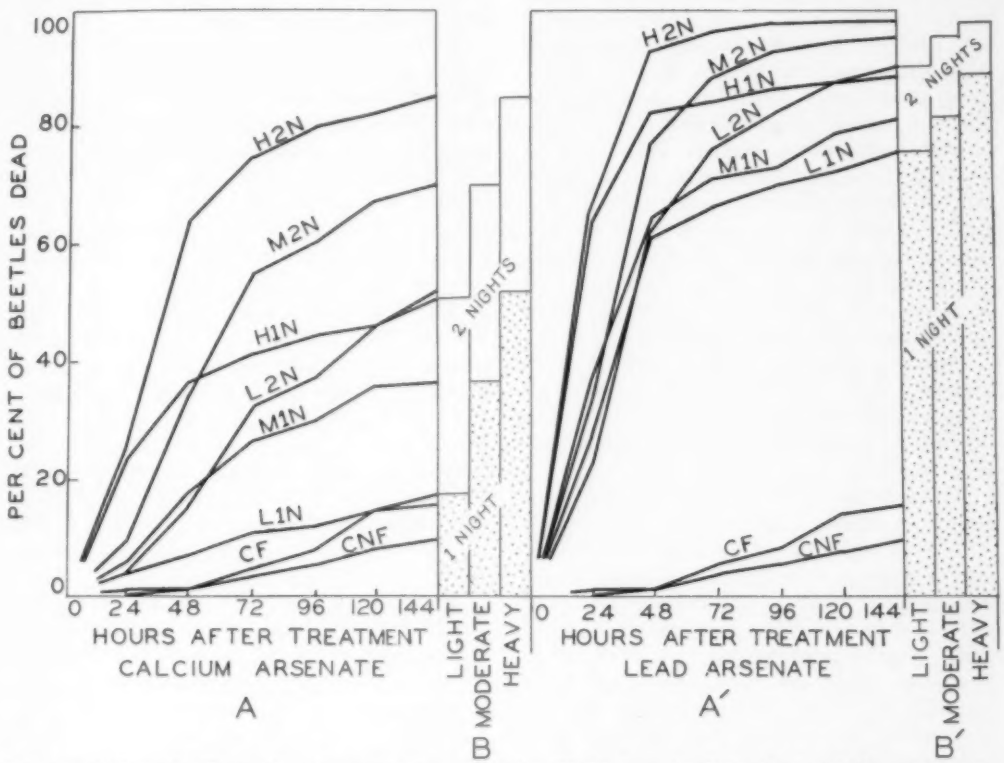

FIG. 1.—*AA'* graphs illustrating the percentages of beetles, *Phyllophaga implicita*, dead at 24-hour intervals after treatment with calcium and lead arsenate. The dosage of the arsenical and the number of nights poisoned foliage was offered is indicated as follows: *H1N*, heavy one night; *H2N*, heavy two nights; *M1N*, moderate one night; *M2N*, moderate two nights; *L1N*, light one night; *L2N*, light two nights; CF, control fed; CNF, control not fed; *BB'* graphs illustrating the differences in effectiveness of one and two nights of treatment as judged by the results 144 hours after treatment with lead and calcium arsenate. Iowa, 1933.

CALCIUM ARSENATE.—The calcium arsenate tests were conducted at the same time as those with lead arsenate, and the same set of controls was used for both series. More of the poisoned foliage was consumed, but the percentage of mortality from the different treatments varied considerably, fig. 1. It should be noted that the results obtained in series II and V are low for the reasons previously noted.

The calcium arsenate used in the M.L. D. experiments (Travis 1936) was analyzed and found to contain CaO, 33.16 per cent; As_2O_5, 31.23 per cent; and water soluble As_2O_5, 0.29 per cent; while that used in the present cage tests was a proprietary sample. The analyzed arsenate was not so toxic as the commercial product to June beetles in these experiments nor to silkworms used in subsequent tests.

MAGNESIUM ARSENATE.—Heavy applications of this insecticide failed to produce mortality significantly greater than that occurring in the controls even though the beetles ate rather freely of the dusted foliage. In one test, where the leaves were

first dipped in water and then rolled in magnesium arsenate, 64 per cent of the beetles were dead 144 hours later.

SODIUM FLUOSILICATE.—Either sodium fluosilicate is only slightly toxic to June beetles, or insufficient amounts were eaten to produce mortality significantly greater than that among the controls.

INERT COMPOUNDS.—None of the following inert compounds tested proved to be noticeably toxic: lime, bentonite, sulfur, whiting, magnesium carbonate, gypsum, diatomaceous earth, kaolin. All of these substances that are employed as fillers in insecticides were fed to the beetle on two successive nights. With sulfur, whiting, lime and bentonite, the average mortality was slightly higher than in the control cages, but the differences are not considered significant. Lead carbonate, which is not used as a diluent, was tested to learn what effect the lead might have upon June beetles; apparently it had none.

SPRAYS.—Lead arsenate and calcium arsenate were also tried in spray suspensions of 1 and 2 pounds of the arsenate to 50 gallons of water, with a potassium soap as a supplement.

The mortality rate in the tests was considerably lower than in the dust series. This was apparently because the willow leaves were so waxy at the time the spray was applied that a uniform spread could not be obtained. The percentages of mortality for the 1 pound mixture were as follows: one night, 12; two nights, 40; for 2 pounds, one night, 62; two nights, 70. The respective percentages for calcium arsenate were 48, 34, 28 and 38.

FIELD TESTS.—When trees which had been dusted with lead arsenate at sundown were examined at midnight, only a few beetles remained, and these were feeding upon leaves practically free of arsenates. Fifty-eight per cent of the beetles collected at that time died within 96 hours. This moderate percentage of mortality, and the fact that the number of beetles observed at midnight was much lower than that observed 3 hours earlier, indicated that the beetles had ceased feeding on the heavily dusted leaves and had departed.

In subsequent tests beetles were collected from the treated trees as soon as they stopped feeding. Of the beetles thus picked from trees dusted with lead arsenate, 80.2 per cent were dead within 96 hours; only 29.3 per cent died within the same period with calcium arsenate as the insecticide. Fifteen per cent of the beetles collected from untreated trees died within the same period.

INDIVIDUAL FEEDING TESTS.—It was observed both in the field and in cage tests that the beetles did not feed readily on foliage dusted with an arsenical. Many individuals would not eat the poisoned foliage the first night offered.

In the individual feeding tests, however, the amount of poison on the foliage seemed to have little effect on the percentages of beetles feeding. In all cases the insects were left in the dishes with the leaves one night. Forty-nine per cent that were offered leaves treated with calcium arsenate, 31 per cent given leaves dusted with lead arsenate and 14 per cent of the control beetles refused to eat.

The average length of time that the beetles fed upon foliage dusted with lead arsenate is as follows: light dosage, 71.1 minutes (range 15–150 minutes); moderate, 60.6 minutes (range 12–99 minutes); heavy, 50.3 minutes (range 10–87 minutes); with calcium arsenate: light, 62.1 minutes (range 21–135 minutes); moderate, 31.3 minutes (range 4–107 minutes); heavy 45.5 minutes (range 16–91 minutes).

In these feeding tests only 5.2 per cent of the beetles returned to feed a second time; 4 per cent of these had been fed lead arsenate and 1.2 per cent calcium arsenate.

Regardless of the length of time they had fed, practically all the beetles that ate the poisoned foliage died within 96 hours. Only two of 92 beetles survived the calcium arsenate experiment and all of the 82 beetles in the lead arsenate tests died. Of the 49 beetles that refused to eat, only 6 died. Of the 174 beetles feeding on poisoned foliage, 79, 16, 3 and 1 per cent died in 24, 48, 72 and 96 hours, respectively. One per cent survived.

DISCUSSION OF DATA.—In general, June beetles are not good subjects for cage tests. They tend to congregate on the sides of the cage and it is frequently necessary to brush them down on to the food offered. In the early evening their movements often knock a considerable proportion of the dust from treated foliage, particularly if the leaves are dry. Furthermore, some of the beetles remain in the soil and do not emerge to feed each night. Individual

feeding experiments showed that a number of beetles failed to eat poisoned foliage when it was offered only one night. However, few beetles survived after feeding only once upon leaves poisoned with lead arsenate or calcium arsenate. No doubt the fact that some beetles did not feed each night was partially responsible for much of the variation in the results of these experiments. The bar graphs, fig. 1, illustrate the differences in effectiveness of lead arsenate and calcium arsenate when offered one and two nights to the same individuals.

In the presentation of the results of these cage tests, the data for the sixth day were selected because mortality of the beetles after that time was obviously not due entirely to effects of the poison, table 1. In the lead arsenate experiments the death curves start to flatten at about 48 hours; in those with calcium arsenate they do not flatten until about 72 hours.

Since the death rate in the male control series was so high, mortality curves for that sex are not presented. In the field, the females are often active as long as 2 weeks after the males of this species have disappeared.

Captive June beetles tend to feed more freely on the kind of foliage upon which they have previously fed—a fact illustrated when *Phyllophaga implicita* adults collected from American elm failed to eat freely of willow leaves in the cage. In nature, beetles of this species could be found in some numbers on willow 2 weeks after they had practically disappeared from elms. Collection records indicate that *P. implicita* feeds most freely on willow and poplar trees.

It appears from these experiments that lead arsenate dusted on the foliage is sufficiently effective as an insecticide to offer some promise in control of June beetles. Calcium arsenate seems less potent than lead arsenate. It should be noted that the waxy coating of the leaves of some plants in the early spring is a handicap to uniform applications of dusts or sprays. When leaves are fully expanded, later, this difficulty is not so evident, but by that time most of the beetles have oviposited.

SUMMARY.—In laboratory tests light applications of lead arsenate dust (1–1½ pounds per tree) killed 74 to 90 per cent of caged June beetles; moderate applications (3 pounds per tree), 81 to 95 per cent; and heavy applications (4½ pounds per tree), 88 to 98 per cent. Similar applications of calcium arsenate dust killed 18 to 52 per cent, 36 to 70 per cent and 51 to 84 per cent, respectively. Magnesium arsenate and sodium fluosilicate did not prove effective. Lead arsenate and calcium arsenate sprays were not so effective as the dusts because the waxy coating of the leaves prevented even coverage. In field tests 80.2 per cent of the beetles died after feeding on foliage dusted with lead arsenate and 29.3 per cent on leaves dusted with calcium arsenate. In individual feeding tests, June beetles fed longer on foliage dusted with lead arsenate than with calcium arsenate.—1-6-39.

LITERATURE CITED

Andre, F., and Philip E. Pratt. 1936. The toxicity of certain stomach poisons to the June beetle, *Phyllophaga implicita* (Horn). Iowa State College Jour. Sci. **10**: 243–8.

Fluke, C. L., and P. O. Ritcher. 1935. Encouraging results in spraying oak trees to reduce white grubs. Wis. Ag. Exp. Sta. Bul. **430**: 7–10.

Smith, J. B. 1889. A case of Lachnosterna damage. Insect Life. **1**: 365–7.

Travis, B. V. 1936. Relative toxicity of certain stomach poisons to *Phyllophaga lanceolata* Say. (Coleoptera-Scarabaeidae). Iowa State College Jour. Sci. **10**: 235–43.

Travis, B. V., and G. C. Decker. 1933. A study on the use of arsenical dusts for the control of June beetles. Iowa State College Jour. Sci. **8**: 493–8.

Vickery, R. A., and T. S. Wilson. 1919. Observations on wingless May beetles. JOUR. ECON. ENT. **12**: 238–47.

T. MCCARTHY, Senior Assistant Entomologist, Department of Agriculture, New South Wales, visited the United States in the early summer and into August, primarily to study methods of grasshopper control in this country. Extended observations of field activities were made in Montana, and the work in Colorado and areas of the northern Great Plains was also studied. Problems relating to the work were discussed by Mr. McCarthy with project workers at the Minneapolis field headquarters and also at Washington, D. C.

PETER BISSET, who has been in charge of the Plant Inspection House in Washington, D. C., for the past 13 years, was retired on April 29, 1939. Mr. Bisset was succeeded by H. S. Dean.

The Role of Calcium Hydroxide in Preventing Hydrogen Sulfide From Decomposing Lead Arsenate

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During recent studies on chemical reactions of lead arsenate–lime sulfur sprays, Ginsburg & Perlgut (1938) have definitely shown that small quantities of hydrogen sulfide, present in spray mixtures, readily decompose acid lead arsenate, releasing large amounts of soluble arsenic, and that calcium hydroxide tends to prevent this reaction. While hydrogen sulfide is generally not present in clear waters, it may be found in waters taken for spraying from stagnant ponds, polluted wells and similar sources where putrefaction of proteinaceous matter takes place. It may also be introduced directly into arsenical sprays by the use of sulfur fungicides. In small quantities it may remain embedded in the caked residue from lime sulfur sprays in uncleaned spray tanks. Finally, H_2S may be formed on foliage by the action of certain organic reducing substances, such as glutathione in leaf tissue and in fungous spores, on sulfur deposited from sulfur fungicides.

This biochemical process of reducing sulfur to H_2S has been well established by many investigators. The work of Marsh (1929), Barker (1929), and Liming & Young (1930) has definitely shown that many species of higher plants are capable of producing H_2S when in contact with sulfur. A more recent investigation of this problem was conducted by McCallen & Wilcoxon (1931). These authors report that "all species of plants tested were found to evolve H_2S when in association with sulfur." Their tests were carried out on the attached leaves of 26 species of higher plants, and on spores of many species of fungi.

Briefly, there seem to be many possibilities for hydrogen sulfide to find its way, directly or indirectly, into arsenical sprays. To what extent this gaseous compound can be held responsible for the continual appearance, year after year, of arsenical injury to apple trees in certain localities, or in some individual orchards within a locality, cannot be definitely stated. That its presence, however, may be a contributing factor in the formation of water soluble arsenic from lead arsenate appears certain.

It was considered advisable to study this problem with the following objects in view: first, to determine to what extent H_2S may influence the decomposition of lead arsenate; second, to determine the concentration of $Ca(OH)_2$ necessary to counteract this reaction; third, to ascertain the exact role that $Ca(OH)_2$ plays in this chemical reaction.

Scope of Experiments.—The entire investigation consists of three series of experiments. The purpose of the first series was twofold: first, to ascertain to what extent hydrogen sulfide is capable of decomposing acid lead arsenate and, second, to determine the concentration of calcium hydroxide required completely to prevent this reaction. In these tests 2 grams $PbHAsO_4$ were added to 500 cubic centimeters of water (approximately 3 pounds per 100 gallons) containing varying concentrations of H_2S with and without different quantities of $Ca(OH)_2$. The mixtures were allowed to stand for about 24 hours at room temperature with frequent shaking and were then filtered. The filtrates were analyzed for soluble arsenic. In addition to the three ingredients being mixed simultaneously, in some tests the $PbHAsO_4$ was first mixed with the H_2S solution, allowed to stand for 24 hours and filtered. The $Ca(OH)_2$ was then added to this filtrate, again shaken for 24 hours, filtered and analyzed for soluble arsenic. In other tests the procedure was reversed. The $Ca(OH)_2$ was first mixed with H_2S solution, and the $PbHAsO_4$ added to the filtrate, etc. The results of this series are given in table 1.

The purpose of the second series was to ascertain the concentration of $Ca(OH)_2$ and the length of time required to change the H_2S into calcium sulfide or other stable sulfur compounds. In these tests no $PbHAsO_4$ was used. Quantities of $Ca(OH)_2$ varying from 0.25 gram to 2 grams were mixed with 500 cubic centimeters of water containing 0.2 gram H_2S. The mixtures stood for different lengths of time,

* Paper of the Journal Series, New Jersey Agricultural Experiment Station, Department of Entomology.

Table 1.—Effect of various concentrations of calcium hydroxide in eliminating soluble arsenic from lead arsenate (2 grams in 500 cubic centimeters) and hydrogen sulfide mixtures.

Test No.	Grams H_2S in 500 cc. Solution	Per Cent H_2S in Solution	Grams $Ca(OH)_2$ Added	Per Cent As_2O_3 Formed	Per Cent $PbHAsO_4$ Decomposed
1	0.05	0.01	None	3.5	12.5
2	0.1	0.02	None	8.2	27.7
3	0.2	0.04	None	11.6	39.0
4	0.4	0.08	None	18.7	65.5
5	0.2	0.04	0.25	5.1	17.85
6	0.2	0.04	0.5	0.45	1.57
7	0.2	0.04	1.0	0.26	0.91
8	0.2	0.04	2.0	0.26	0.91
9	0.4	0.08	2.0	0.42	1.5
10	0.2	0.04	2.0*	0.43	1.5
11	0.4	0.08	2.0*	0.40	1.4
12	0.2	0.04	2.0†	0.43	1.5
13	0.4	0.08	2.0†	0.43	1.5
14	0.4	0.08	4.0†	0.24	0.84
15‡	None	None	None	0.21	0.73

* $Ca(OH)_2$ added to filtrates from $H_2S+PbHAsO_4$ mixtures.
† $PbHAsO_4$ added to filtrates from $H_2S+Ca(OH)_2$ mixtures.
‡ Check, $PbHAsO_4$ only.

with frequent shaking, in glass stoppered bottles and were then filtered. The amounts of free H_2S still remaining in the filtrates were then determined. The results from this series are given in table 2.

Table 2.—Concentrations of calcium hydroxide necessary completely to react with hydrogen sulfide during different periods of standing.

Test No.	Reaction Period in Hours	Grams $Ca(OH)_2$ Added	Hydrogen Sulfide: Grams in 500 Cubic Centimeters Solution	Hydrogen Sulfide: Quantity Recovered, Grams	Hydrogen Sulfide: Quantity Recovered, Per Cent	Per Cent Reacted With $Ca(OH)_2$
16	20.0	0.25	0.2	0.003	1.5	98.5
17	20.0	0.3	0.2	0.003	1.5	98.5
18	20.0	2.0	0.2	0.002	1.0	99.0
19	1.0	2.0	0.2	0.003	1.5	98.5
20	0.5	2.0	0.2	0.02	10.0	90.0
21 (Blank)	20.0	2.0	None	0.002	1.0	—

In order definitely to identify the sulfur compounds into which the H_2S is changed by the action of $Ca(OH)_2$, the third series of tests was carried out. Filtrates from 500 cubic centimeter mixtures containing 0.17 gram H_2S with either 2 or 4 grams $Ca(OH)_2$, after 24 hours shaking, were analyzed for sulfur as sulfide, thiosulfate and sulfate. The results from this series are given in table 3.

MATERIALS AND METHODS.—A standard commercial brand of acid lead arsenate, chemically pure calcium hydroxide, distilled water and laboratory prepared hydrogen sulfide were employed. The H_2S was prepared in an improvised Kipp generator by the action of hydrochloric acid on ferrous sulfide. The gas was washed by being passed through two reagent bottles of water and was finally in-

Table 3.—Sulfur compounds formed when calcium hydroxide reacts with hydrogen sulfide.

$Ca(OH)_2$ added to mixture (grams)	2.0	4.0
H_2S added to mixture (grams)	0.17	0.17
S, as H_2S added to mixture (grams)	0.16	0.16
S, as sulfide found in filtrates (grams)	0.152	0.158
S, as thiosulfate found in filtrates	Trace	Trace
S, as sulfate found in filtrates	None	None
H_2S changed to calcium sulfide (per cent)	95.0	98.0

troduced into a large flask of distilled water. The generation was allowed to go on for about 1 hour, or until the water became fairly saturated with H_2S. The exact concentration of hydrogen sulfide was then determined by the following method: Aliquot samples were treated with an excess of N/10 iodine and back titrated with N/10 sodium thiosulfate. From the number of cubic centimeters iodine solution used up, the amount of H_2S was determined. The actual amount of H_2S thus incorporated in the water varied from 0.1 to 0.15 per cent, depending on the temperature. This served as a stock solution, which was further diluted with water to any desired concentration of H_2S. Fresh stock solutions were prepared immediately before tests were conducted.

Because iodine also reacts with calcium sulfide and thiosulfate, a different procedure was employed for analyzing H_2S in filtrates from $Ca(OH)_2$ mixtures. The bottle containing the filtrate was connected to a suction water pump; air was aspirated through the solution at the rate of 1 gallon per minute and received in duplicate reagent bottles, each containing 50 cubic centimeters N/10 iodine. The excess iodine was then titrated with N/10 sodium thiosulfate. Preliminary tests indicated that about 45 minutes of aeration was sufficiently long to remove all of the H_2S from 500 cubic centimeters. This period was, therefore, used in all tests where aeration was required.

For the analyses of sulfur as sulfide, thiosulfate and sulfate, the methods outlined by the Association of Official Agricultural Chemists (1935) were followed.

Soluble arsenic was determined by the following method: To 200 cubic centimeters of filtrate add 6 cubic centimeters of concentrated H_2SO_4; boil down to about 50 cubic centimeters or until all the sulfur has precipitated, leaving a clear solution upon cooling, and filter. This procedure eliminates sulfides and thiosulfates. From here on the method is exactly the same as that outlined by Mahin & Carr (1923). Dilute the filtrate with distilled water to 100 cubic centimeters; add 2 cubic centimeters of 50 per cent KI and evaporate to about 40 cubic centimeters; cool, dilute to about 150 cubic centimeters; remove the iodine with $Na_2S_2O_3$, add phenolphthalein indicator and nearly neutralize with 40 per cent NaOH. Add an excess of $NaHCO_3$ and titrate the arsenic with N/40 iodine using starch as indicator. From the number of cubic centimeters iodine solution used, the per cent soluble arsenic is determined as As_2O_3. From these results the approximate per cent $PbHAsO_4$ decomposed was calculated.

All chemical analyses were made in duplicate and were repeated wherever the data of the two samples showed appreciable variations. Averages of the results are presented in the tables.

EFFECT OF H_2S ON DECOMPOSING LEAD ARSENATE.—The results in table 1 definitely show that H_2S forms large amounts of soluble arsenic from acid lead arsenate (tests 1, 2, 3, 4). Concentrations of H_2S as low as 0.01 per cent decomposed about 12.5 per cent $PbHAsO_4$. Increasing the H_2S concentrations resulted in proportional increases of soluble arsenic.

EFFECT OF $Ca(OH)_2$ ON PREVENTING DECOMPOSITION OF LEAD ARSENATE.—The data in table 1 definitely indicate that $Ca(OH)_2$ when added in sufficient quantities, stops the reaction between H_2S and $PbHAsO_4$. Apparently 1 gram $Ca(OH)_2$ is the minimum quantity necessary to counteract 0.2 gram H_2S, as may be seen from test 7. In the filtrate from this mixture the per cent soluble arsenic was approximately the same as in the check, where no H_2S was present. It further appears, from a comparison of the data in table 1, that $Ca(OH)_2$ plays here a double role. It prevents the decomposition of $PbHAsO_4$ by reacting with the H_2S to form less reactive or non-reactive sulfur compounds, as shown by tests 12, 13 and 14. It also removes the soluble arsenic formed by the reaction of H_2S and $PbHAsO_4$, as shown by tests 10 and 11, converting the soluble arsenic into insoluble calcium arsenate. When $Ca(OH)_2$ is added to H_2S-$PbHAsO_4$ mixtures both reactions probably take place.

EFFECT OF CALCIUM HYDROXIDE ON HYDROGEN SULFIDE.—The results in table 2 suggest that about 1 hour is the minimum length of time required for 0.2 gram H_2S practically completely to disappear in the presence of an excess of $Ca(OH)_2$, test 19. When the mixtures stood a half hour, 2 grams $Ca(OH)_2$ reacted only with 90 per cent of the 0.2 gram H_2S. Samples standing 20 hours showed practically com-

plete elimination of hydrogen sulfide from solution in all the concentrations of calcium hydroxide used.

Examining the results in table 3, it becomes evident that calcium hydroxide changes the hydrogen sulfide almost entirely to calcium sulfide, since only traces of thiosulfate and no sulfate were found in the filtrates. No appreciable differences were observed between the effect of 2 and 4 grams calcium hydroxide on 0.17 gram hydrogen sulfide. In each case the reaction was practically complete, giving from 95 to 98 per cent calcium sulfide.

Apparently, converting H_2S into CaS does not prevent decomposition of $PbHAsO_4$ (test 5), unless an excess of $Ca(OH)_2$ is present. The reason for this is that calcium sulfide by itself, in low concentrations, tends to decompose lead arsenate, as shown by Ginsburg & Perglut (1938).

SUMMARY AND CONCLUSIONS.—A study was made on the decomposition of acid lead arsenate by hydrogen sulfide in spray mixtures, and means of preventing this reaction. Lead arsenate was mixed with water containing various concentrations of hydrogen sulfide, with and without different quantities of calcium hydroxide. The filtrates of these mixtures were analyzed for soluble arsenic. Chemical analyses were also made of the sulfur compounds formed from the reaction of H_2S and $Ca(OH)_2$. The results suggest the following conclusions:

Small quantities of hydrogen sulfide decompose acid lead arsenate, forming large amounts of soluble arsenic. Calcium hydroxide readily reacts with hydrogen sulfide, changing it to calcium sulfide. An excess of calcium hydroxide is required to prevent the decomposition of lead arsenate by hydrogen sulfide.—1-6-39.

LITERATURE CITED

Association of Official Agricultural Chemists. 1935. Official and Tentative Methods of Analysis. Ed. 4. Washington, D. C.

Barker, B. T. P. 1929. Investigations on the fungicidal action of sulfur: IV. third progress report, Long Ashton Ag. & Hort. Res. Sta. Ann. Rep., pp. 130–48.

Ginsburg, J. M., and L. E. Perlgut. 1938. Chemical reactions of lead arsenate—lime sulfur sprays. N. J. Ag. Exp. Sta. Bul. 655.

Liming, O. N., and H. C. Young. 1930. Toxicity of sulfur to spores of *Sclerotinia cinerea* as affected by the presence of pentathionic and other sulfur acids. Jour. Ag. Res. 40: 951–62.

Mahin, G. M., and R. H. Carr. 1923. Quantitative Agricultural Analysis. McGraw-Hill Book Company, Inc. New York.

Marsh, R. W. 1929. Investigations on fungicidal action of sulfur. III. Studies on the toxicity of sulphuretted hydrogen and on the interaction of sulfur with fungi. Jour. Pomol. & Hort. Sci. 7: 237–9.

McCallan, S. E. A., and F. Wilcoxon. 1931. The fungicidal action of sulphur. II. The production of hydrogen sulphide by sulphured leaves and spores and its toxicity to spores. Boyce Thompson Inst. 3: 13–38.

Effects of Heat Treatments of Some Calcium Arsenates on Their Toxicity to Silkworms and Bean Plants

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The chief limitation in the use of calcium arsenate as an insecticide has been its variability in composition and properties, particularly in toxicity to plants. Howard & Fletcher (1933) in 1929 tested 19 commercial brands of calcium arsenate and reported them to be extremely variable in toxicity to plants. Chemical analyses of 16 of these samples by Smith & Murray (1931) did not reveal any correlation between their chemical constitution and their toxicity to bean foliage. Later studies by Howard & Davidson (1935) on five of the most toxic of these preparations indicated that autoclaving for 2 hours at 150 pounds' pressure rendered them safe to bean foliage. The present work on calcium arsenates of known composition was undertaken to study the effect of heat treatments on their toxicity to insects and plants.

* The writers acknowledge material assistance rendered by Mrs. Abby H. Casanges.

MATERIALS AND THEIR TREATMENT.—

The samples of calcium arsenate tested were treated in three different manners—by igniting, dry heating and autoclaving.

In 1935 pure calcium arsenates of four different ratios of CaO to As_2O_5 were prepared—monocalcium arsenate ($CaO \cdot As_2O_5 \cdot 2H_2O$), two dicalcium arsenates ($2CaO \cdot As_2O_5 \cdot 3H_2O$ and $2CaO \cdot As_2O_5 \cdot 5H_2O$), tricalcium arsenate ($3CaO \cdot As_2O_5 \cdot 8H_2O$) and tetracalcium arsenate ($4CaO \cdot As_2O_5 \cdot XH_2O$). A sample of each was ignited

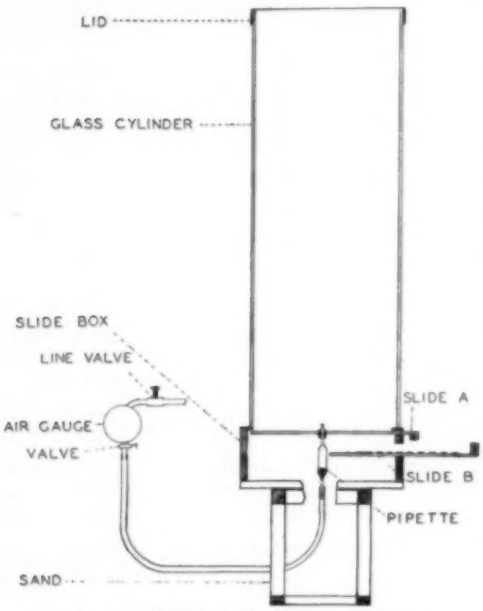

FIG. 1.—Modified dusting apparatus.

to a glowing red to obtain the corresponding anhydrous compound.

In 1936 a commercial sample equivalent to tetracalcium arsenate was studied. Eight portions of this sample containing about 4 per cent of free calcium hydroxide were heated, four by autoclaving and four by dry heating. Three of the autoclaved portions were in such a physical state after the treatment that drying was necessary before they could be dusted. The specific treatments are given in table 2.

TOXICITY TO SILKWORMS.—Fourth-instar silkworms, *Bombyx mori* L., were used as test insects. In feeding the material the sandwich method of Campbell & Filmer (1929), as modified by Bulger (1932), was used. To avoid the necessity of lifting the dusting cylinder, a further modification was made, fig. 1. A box 13 inches square and 4 inches high was constructed with an upper slide, *A*, designed with a hole in the center to hold the dusting pipette and to catch the coarse settlings, and a lower slide, *B*, to hold the leaf disks to be dusted.

A glass cylinder 33 inches high was placed on top of the slide box. With slide *A* in place, a pipette containing a charge of dust was inserted in the hole, the dust blown into the cylinder and the pipette removed. Slide *B*, containing the leaf disks to be dusted, was then inserted below slide *A*. During this operation, which required about 20 to 30 seconds, the coarser particles settled upon the slide. Slide *A* was then quickly withdrawn and the fine dust permitted to settle upon the leaf disks on slide *B*. The length of time for the second settling depended upon the deposit desired. When very heavy deposits were desired, the dusting was repeated two or three times on the same set of leaf disks, slide *B* being carefully removed and reinserted after each dusting.

In the 1935 tests the photographic-planimeter method of Campbell & Filmer (1929) was used for determining the area consumed by a worm. In 1936 the inlay-sandwich method (Bulger 1937) was used except where doses of more than 0.7 milligram per gram of body weight were desired, when the photographic-planimeter method was employed.

No attempt was made in these tests to establish small differences in relative toxicity by determination of median lethal doses. Instead, the results are stated as a median lethal dosage range, which include that group of doses, expressed in milligrams per gram of body weight, within which the median lethal dose may be expected to lie.

As shown in table 1, all the hydrous calcium arsenates of the 1935 series were fairly toxic to silkworm larvae, whereas the corresponding anhydrous compounds produced by ignition were practically nontoxic.

The ignited dicalcium arsenate (I.D. 3076) was the most variable in its toxicological results. There was considerable evidence that a median lethal dose in the range 0.55 to 0.74 might be established, since in this range there were 30 living and 29 dead larvae. However, of the 41 insects which consumed larger doses than

Table 1.—Toxicity of various calcium arsenates, with and without heat treatment, to silkworm larvae and bean plants (1935).

I.D. No.	Chemical Formula	Treatment	Chemical Analysis			Mortality Data						Degree of Plant Injury
			Total CaO, Per Cent	Total As_2O_5, Per Cent	Water-soluble As_2O_5,* Per Cent	M.L.D. Range, Magnesium Per Gram	Maximum Dose, Magnesium Per Gram	Insects in M.L.D. Range		Total Insects that Fed		
								Number Living	Number Dead	Number Living	Number Dead	
3074	$CaO \cdot As_2O_5$	Ignited	19.6	80.4	0.3	†	4.71	—	—	89	0	None
3075	$CaO \cdot As_2O_5 \cdot 2H_2O$	None	17.3	71.4	71.4	0.04–0.05	—	9	12	23	94	Dead
3076	$2CaO \cdot As_2O_5$ (from 3078)	Ignited to glowing red to constant weight	32.9	67.2	9.4	‡	1.20	—	—	102	60	Very slight
3078	$2CaO \cdot As_2O_5 \cdot 3H_2O$	None	28.7	58.1	32.2	0.04–0.05	—	9	10	26	53	Severe
3077	$2CaO \cdot As_2O_5$ (from 3079)	Ignited to glowing red to constant weight	32.8	67.2	16.0	§	—	—	—	—	—	Slight
3079	$2CaO \cdot As_2O_5 \cdot 5H_2O$	None	25.7	53.0	32.8	§	—	—	—	—	—	Severe
3122	$3CaO \cdot As_2O_5$ (from 3081)	Ignited for 3 hours at 500°C.	41.7	57.1	4.0	0.17–0.18	—	19	22	39	49	Dead
3367	$3CaO \cdot As_2O_5$ (from 3081)	Ignited for 3 hours at 800°C.	41.9	56.4	1.8	†	1.46	—	—	11	0	Severe
3081	$3CaO \cdot As_2O_5 \cdot 8H_2O$	None	32.1	42.9	3.3	0.08–0.09	—	10	27	64	69	Severe
3082	$4CaO \cdot As_2O_5$	Ignited to glowing red for 2 hours	47.9	48.9	0.1	†	2.26	—	—	77	6	Very slight
3083	$4CaO \cdot As_2O_5 \cdot XH_2O$	None	42.1	42.8	1.8	0.10–0.12	—	4	6	24	56	None

* Determined by A.O.A.C. method.
† Insufficient mortality to establish an M.L.D. range.
‡ There was some indication that a median lethal dose might be established between 0.55 and 0.74 milligrams, but too many survivas were recorded above this figure to consider this range conclusive.
§ Toxicity tests on insects not made.

the maximum of this range, 26 survived and only 15 died. Since the work indicated clearly that ignition of this compound greatly reduced its toxicity, and since the number of insects available was limited, it was considered undesirable to continue the tests further.

The tricalcium arsenate ignited at controlled temperatures (I.D. 3081) did not show a great loss in toxicity when heated 3 hours at 500 degrees C. (I.D. 3122), but when heated for the same length of time at 800 degrees C. (I.D. 3367) it became relatively nontoxic.

When toxicity to both insects and plants was considered, tetracalcium arsenate was the most promising. Therefore, in 1936 only tetracalcium arsenate was used.

In table 2 are given data showing the effect of autoclaving and dry heating a commercially prepared tetracalcium arsenate upon its toxicity. When autoclaved at 100 degrees C. for 1 hour and dried at the same temperature for one-half hour, the preparation was still fairly toxic. However, when the period of autoclaving was extended to 3 hours and the period of drying to 1 hour, or when the autoclaving

Table 2.—Toxicity of tetracalcium arsenate that has been treated by autoclaving or dry heating to silkworm larvae and bean plants (1936).

I.D. No.	Treatment		Chemical Analyses			Mortality Data						Degree of Plant Injury
	Temperature, Degrees C	Time, Hours	Total CaO, Per Cent	Total As_2O_5, Per Cent	Water-soluble As_2O_5,* Per Cent	M.L.D. Range, Milligrams Per Gram	Maximum Dosage Fed, Milligrams Per Gram	Insects in M.L.D. Range		Total Insects		
								Number Living	Number Dead	Number Living	Number Dead	
	Autoclaved											
3311A	100	1†	40.5	40.1	3.6	0.10–0.11	—	6	9	11	19	Considerable
3310A	100	3‡	42.2	40.2	0.7	—	4.00	—	—	18	6	Very slight
3309A	182	1‡	38.6	32.5	0.5	—	3.61	—	—	30	2	Very slight
3308A	182	3	38.9	37.2	0.5	—	3.81	—	—	11	5	Slight
	Dry heat											
3315A	100	3	39.8	38.8	4.2	0.09–0.10	—	5	15	5	33	Considerable
3314A	180	3	39.1	40.1	4.5	0.12–0.13	—	4	20	5	60	Considerable
3313A	500	½	45.9	44.5	0.3	—	6.53	—	—	16	0	None
3312A	500	1	45.8	44.0	0.3	—	5.34	—	—	19	1	None
	Untreated											
2854A			40.9	38.2	3.3	—	—	—	—	—	—	Considerable

* Determined by the Geneva method.
† Followed by drying at 100 degrees C. for one-half hour.
‡ Followed by drying at 100 degrees C. for 1 hour.

was carried on at 182 degrees C. for 1 hour or more, it became relatively nontoxic. Dry heating for 3 hours at 100 degrees and 180 degrees C. had little effect on the toxicity, whereas heating for one-half hour or more at 500 degrees C. made the preparation relatively nontoxic.

TOXICITY TO PLANTS.—To determine the degree of tolerance of plants to the calcium arsenates used in this study, beans (Red Valentine) were grown in pots in the greenhouse, and plants of the same age and size were sprayed on the same day with each of the calcium arsenates listed in tables 1 and 2. The preparations listed in each table were treated as a series. Three replications of each series of sprayings were made at intervals of about 10 days. The sprays were made to contain 3 pounds of the calcium arsenate to 100 gallons of water. They were applied with a small hand sprayer, care being taken to keep them well agitated during the application. Each plant was thoroughly wet with the spray and then placed in the greenhouse for daily observations over a period of 8 days. The degree of injury was designated as none, very sight, slight, considerable, severe, very severe and plants dead, which corresponded, respectively, to the destruction of approximately 0, 3, 5, 25, 50, 75 and 100 per cent of the foliage area.

As shown in tables 1 and 2, ignition or the degree of heat, either dry or in autoclaving, which rendered the preparation nontoxic to silkworm larvae likewise made it relatively nontoxic to bean foliage.

TESTS OF DUSTING METHOD.—Since the tetracalcium arsenate tested in 1936 contained some free calcium hydroxide, preliminary tests were made to determine whether in the method of dusting there was a separation of free calcium hydroxide and calcium arsenate which might cause the former to be deposited with the fine particles of calcium arsenate in a proportion greater than occurred in the original sample. Samples of dust similar to that deposited on the leaf disks were collected from three preparations, one of which was known to contain considerable uncombined calcium hydroxide and analyzed for determination of the $CaO:As_2O_5$ ratio.* The results of these analyses showed that no separation had occurred. It was therefore certain that any decrease in toxicity observed was not due to an excessive deposit of free lime during the dusting process, but was a valid toxicological difference.

SUMMARY AND CONCLUSIONS.—Four hydrous calcium arsenates of typically different composition were ignited to produce the corresponding anhydrous preparations, and eight portions of a sample of commercial tetracalcium arsenate were autoclaved or treated with dry heat. A portion of each preparation was then fed to silkworm larvae, *Bombyx mori* L., by the sandwich method and their toxicity determined in terms of the median lethal dosage range. Plant tolerance of these calcium arsenate preparations was determined by applying them to bean foliage in the greenhouse and estimating the degree of foliage destruction.

All the hydrous calcium arsenates were fairly toxic to silkworm larvae. Monocalcium and dicalcium arsenates were the most toxic and about equal in toxicity, notwithstanding the fact that the amount of soluble arsenic present varied greatly. Tricalcium and tetracalcium arsenates were only about half as toxic as the monocalcium and dicalcium compounds. The anhydrous form of each compound tested was nontoxic to the extent that when large doses were fed (12 to 50 times the M.L.D. for hydrous forms) no median lethal dosage range was established.

In general, ignition decreased the percentage of soluble arsenic present. However, there does not appear to be any appreciable correlation between the percentage of soluble arsenic as determined by the A.O.A.C. method and the toxicity to insects or plants.

Heat treatments of calcium arsenate sufficiently severe to make the product relatively safe to bean foliage likewise make it nontoxic to silkworm larvae. The fact that autoclaving at 100 degrees C. for 1 hour does not destroy the toxicity, whereas the same treatment for 3 hours produces a relatively nontoxic tetracalcium arsenate, suggests that the toxicity balance of such a calcium arsenate is rather delicate and indicates that great care should be exercised in its preparation if the toxicity is to be maintained.

Dry heating at controlled temperatures does not affect the toxicity of tricalcium arsenate so readily as that of tetracalcium arsenate.—1-6-39.

* Unpublished work by C. C. Cassil.

LITERATURE CITED

Bulger, J. W. 1932. Additions to our knowledge of the toxicity of stomach poisons to insects. JOUR. ECON. ENT. **25**(2):261–8. April. 2 figs.

Bulger, J. W. 1937. Feeding predetermined doses of poisons to silkworms. JOUR. ECON. ENT. **30**(5): 689–93. Oct. 3 figs.

Campbell, F. L., and R. S. Filmer. 1929. A quantitative method of estimating the relative toxicity of stomach-poison insecticides. IV. Internatl. Cong. Ent. Trans. 1928 **2;** pp. [523]–533. Illus.

Howard, Neale F., and Ralph H. Davidson. 1935. Effect of heat treatment on toxicity of calcium arsenate to bean foliage. Sci. Note. JOUR. ECON. ENT. **28**(1):250. Feb.

Howard, Neale F., and Fred W. Fletcher. 1933. The effect of various commercial calcium arsenates on bean foliage. U. S. Dept. Ag. Bur. Ent. and Pl. Quar., E-304. Mimeographed. 31 pp.

Pearce, G. W., L. B. Norton and P. J. Chapman. 1935. A chemical method of determining the safeness to foliage of commercial calcium arsenates. N. Y. State Ag. Exp. Sta. Tech. Bul. **234.** 15 pp.

Smith, C. M., and C. W. Murray. 1931. The composition of commercial calcium arsenate. Indus. and Engin. Chem. **23**(2):207–8. Feb.

Present Status of the European Spruce Sawfly, *Diprion polytomum* (Htg.), in the United States

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In 1930 the European spruce sawfly, *Diprion polytomum* (Htg.), was discovered causing serious defoliation of spruce in the Gaspé Peninsula of Canada. Since that time about 60 per cent of the white spruce and 25 per cent of the black spruce have been killed over an area of approximately 3,000 square miles in that region. The insect has also become prevalent in from medium to heavy infestations throughout New Brunswick, the whole of the Gaspé Peninsula and a large area in the Province of Quebec on both sides of the St. Lawrence River. In the United States it is present in outbreak form in northern Maine and at several points in Vermont and New Hampshire. Fig. 1 shows the known distribution at the present time. R. E. Balch (1934–1938b) of the Dominion Entomological Laboratory at Fredericton, New Brunswick, has given several valuable reports regarding the progress of the sawfly infestation in Canada with notes on the biology of the insect, and in 1936 H. J. MacAloney (1936a, b, c, d), of the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, gave short accounts of the insect in the United States.

SURVEYS TO DETERMINE RANGE AND SERIOUSNESS.—During 1937 and 1938 the Bureau of Entomology and Plant Quarantine, in cooperation with the states of Maine, New Hampshire, Vermont and New York and various lumber companies, conducted an intensive survey to determine the range of the insect and seriousness of the infestations in this country. The purpose of the present paper is to give an account of the work and results of this survey and to report the parasite liberations that have been made against the pest.

Most of the survey work of 1937 was done in Maine under the direction of H. J. MacAloney. Six trained men were employed by the Bureau of Entomology and Plant Quarantine in this work throughout the summer season. Owing to the scarcity of public roads in much of the northern part of the state, considerable survey work was done from the principal water courses and logging roads. The Maine Forest Service made its fire patrolmen available as guides, and representatives of the Great Northern Paper Company, American Realty Company, Penobscot Development Company, Eastern Manufacturing Company, Passamaquoddy Land Company, Maine Seaboard Paper Company, and the Hollingsworth and Whitney Company guided survey men through their holdings. Scouting work along the coast of Maine and in some areas along the New Brunswick and Quebec borders was carried out by workers from the office of the state entomologist.

In 1938 the township was used as a basis for the survey work, all of which was carried out in New Hampshire, Vermont and New York. Practically all the townships within the known spruce area of these states were covered. In

most of the townships topographic maps were used, upon which were marked the spruce areas and the points where inspections were made. Where spruce was nearly continuous, inspections were made practically every mile. Each inspection consisted of beating a few branches for larvae, looking in likely places for cocoons, inspecting the ground for frass and noting the degree of defoliation. In most of the townships all the passable roads were covered, and spruce that was not accessible from the roads was visited by hiking in at various points. The number of inspections depended largely upon local conditions. A separate sheet for each township listed at the different inspection points the acreage, the forest type and the intensity of the infestation. The Bureau of Entomology and Plant Quarantine provided six men for the survey work in New Hampshire and Vermont, while each of these states provided two men. In northern New Hampshire the Coe and Pingree Estate, Brown Company, Groveton Paper Company and the New Hampshire-Vermont Lumber Company supplied guides to help conduct the survey on their lands. Observations on the White Mountain and Green Mountain National Forests were made by the Forest Service of the U. S. Department of Agriculture, while the state of New York did all its own survey work.

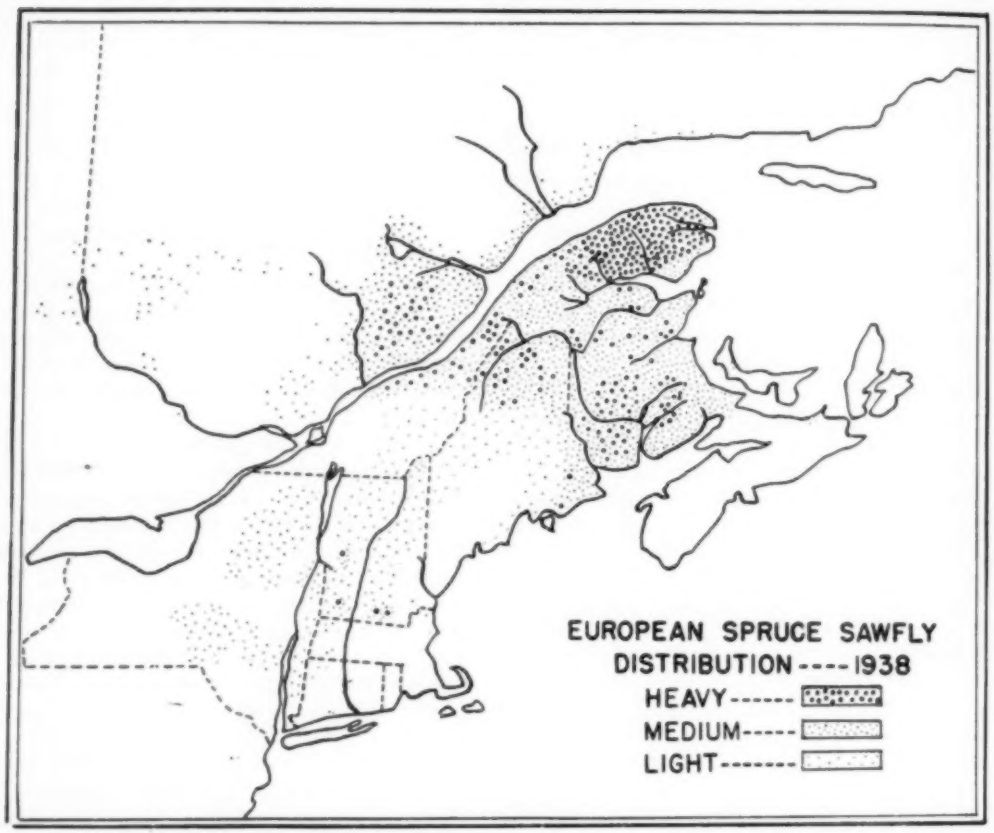

FIG. 1.—General distribution of the European spruce sawfly, *Diprion polytomum* (Htg.), in America, 1938. *Heavy* indicates severe defoliation where most of the old foliage has been consumed; *medium* indicates a slight but noticeable defoliation; *light* indicates larvae present but no noticeable feeding.

In general, the survey showed that the spruce sawfly was present in at least small numbers wherever inspections were made. Fig. 2 shows the area scouted, with *heavy* and *medium* infestations noted.

In Maine the survey of 1937 disclosed medium to heavy infestations in eight townships near the St. John River Valley; two townships in the lower part of the Allagash Valley; one township just north

of Portage Lake; in Ashland, Chapman and the Chesuncook Plantation. It was estimated that 15,000 acres showed noticeable defoliation. No survey work was done by the Bureau of Entomology and Plant Quarantine in Maine during 1938, but reports from the office of the state entomologist indicate that there has been a marked increase in the intensity of the infestation in northern Maine, and that four townships northeast of Devereaux in Washington County are now reported heavily infested. These were only lightly infested a season ago.

In New Hampshire a very heavy infestation was discovered in September, 1937, at Dublin, on the northern slope of Mt. Monadnock. This infestation involved more than 4,000 acres of merchantable red spruce. At the same time a small area about 10 miles east of this point, near the Temple-Peterboro line, was found similarly affected. These infestations remain very severe and have spread outward a short distance. Most of the trees in these areas have been stripped of all their old foliage and from 25 to 75 per cent of their new foliage. The trees most heavily fed upon in 1937, however, appeared in somewhat better condition in 1938, for they put on a good growth of foliage in the spring and were not so severely fed upon as were the surrounding trees. Unfortunately, though, this area was severely damaged by the recent hurricane, and most of the trees were blown down. The only other point in New Hampshire where the infestation can be

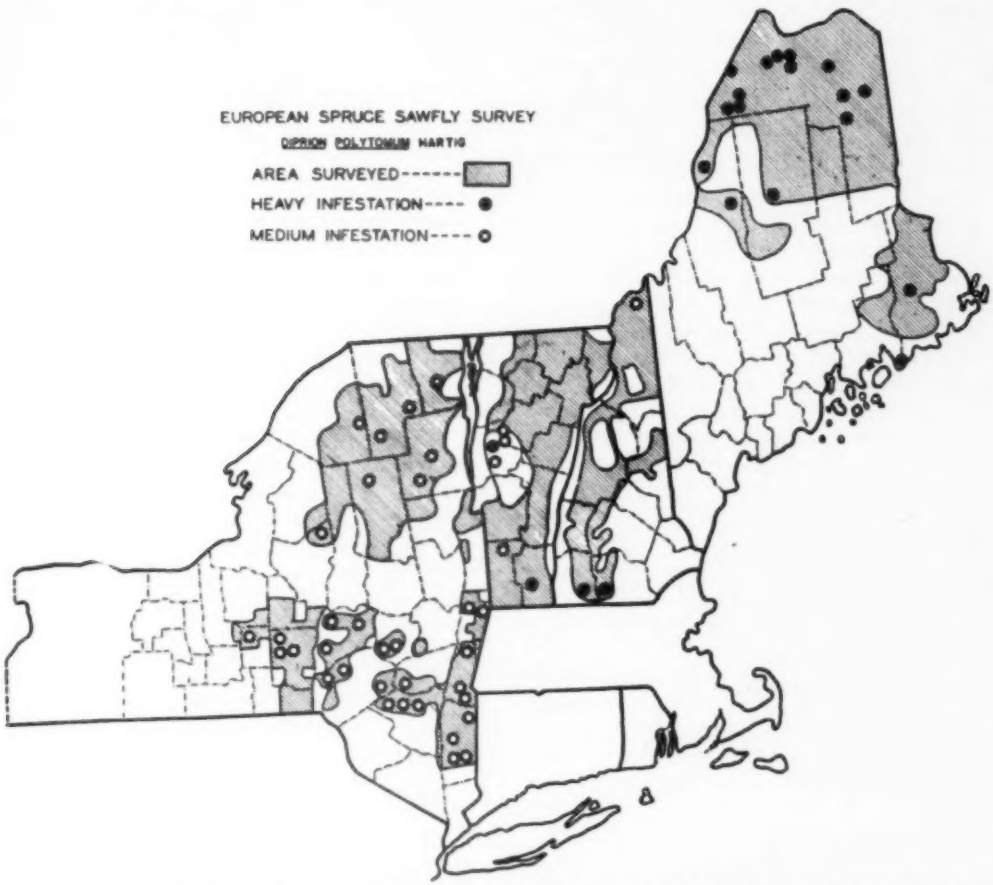

FIG. 2.—European spruce sawfly survey. Shaded area indicates survey conducted in 1937 and 1938 by state organizations in cooperation with the Bureau of Entomology and Plant Quarantine of the U. S. Department of Agriculture. Black circles indicate heavy infestations and rings medium infestations in 1938.

called medium to heavy is at the extreme northern part of the state in Pittsburg. On Mt. Kent and along Scots Bog Ridge from 20 to 35 sound cocoons were found at a number of inspection points, but no noticeable defoliation was observed.

In Vermont two heavy infestations were discovered in 1937, one at Lincoln in the central portion of the state and one at Wilmington near the southern border. The infestation at Lincoln affected several thousand acres of pasture red spruce and extended up the slope of Mt. Abraham. At Wilmington about 2,000 acres of pasture spruce were heavily infested. The survey of 1938 showed medium infestations with slight but noticeable defoliation on Mt. Ellen, Mt. Abraham and Mt. Battell in the vicinity of Lincoln, and on Green Peak in Dorset. The infestation at Lincoln is apparently less severe than it was in 1937. At Wilmington conditions are worse than they were in 1937. The infestation is very severe and it has spread in a northerly and easterly direction into the townships of Dover, Newfane and Marlboro. As at Monadnock, the trees most heavily fed upon in 1937 appeared better this season than they did last.

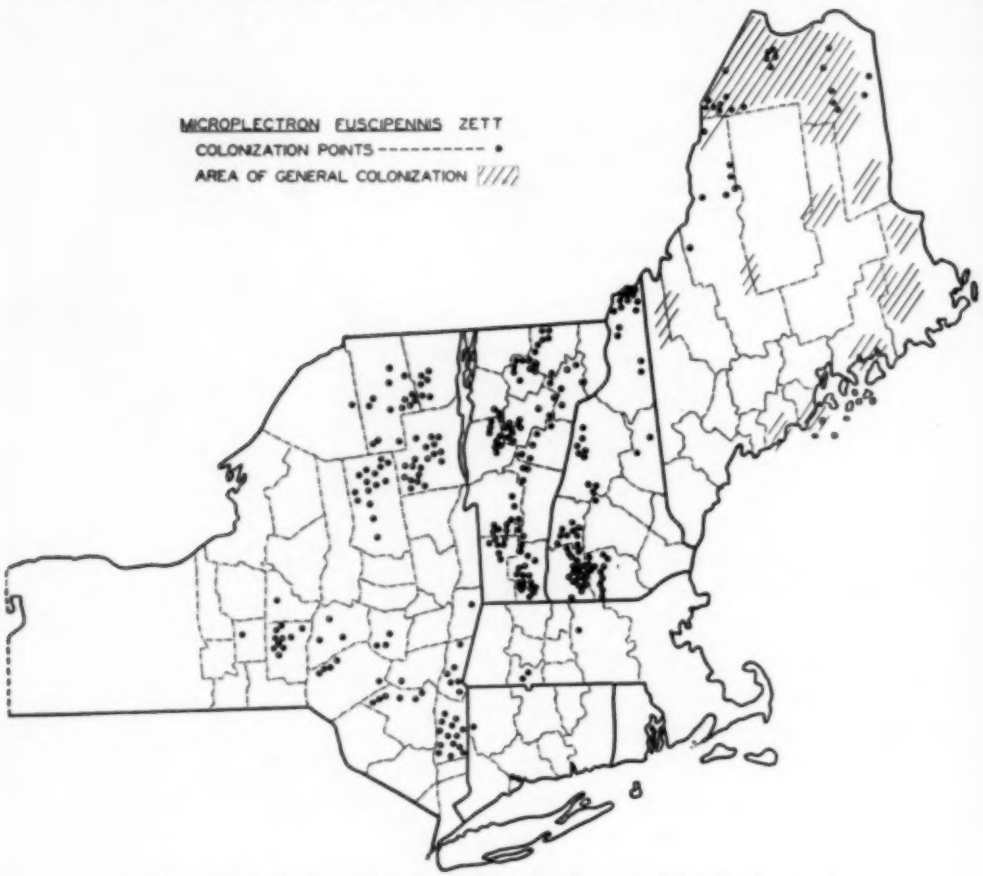

FIG. 3.—Colonization points of *Microplectron fuscipennis* Zett. and area of general colonization in Maine through 1938.

In New York conditions are somewhat different. The sawfly is quite numerous in some older, natural stands in the Adirondacks but no defoliation has been observed there. On the other hand a few plantations of young Norway spruce, from 10 to 30 years old, are from medium to heavily infested and show noticeable defoliation both in the Adirondack region and in the southeastern part of the state. These points have been indicated in fig. 2 as *medium* infestations.

Up to the present time the number of trees actually killed in the United States

still remains small. Some mortality, apparently caused by sawfly defoliation or a combination of sawfly feeding and drought, has been observed in the Allagash Valley and along the St. John River in Maine, at Monadnock in New Hampshire and around Wilmington in Vermont. Nevertheless trees over a large area in these localities have been so severely defoliated that it seems questionable whether they can survive. According to Balch (1936) trees so severely defoliated that they cannot recover will generally show no signs of death until the following year and some will even put out a good growth of new foliage for 1 or more years before they finally die. Although almost complete defoliation is necessary to cause death, trees are in danger of being killed if practically all the old foliage and more than 50 per cent of the new foliage is destroyed. Studies in the United States have not been carried on long enough to show any marked differences between the habits of the insect and the result of defoliation in Canada and in this country. There seems little doubt that conditions in New Brunswick and northern Maine are very similar. Farther south most of the natural growth is red spruce, whereas in the Gaspé region white spruce has suffered the heaviest mortality. In that region also a high percentage of the cocoons remain in diapause for more than 1 year, and 20 per cent adult emergence is considered normal. This tendency is apparently much less common in southern New Hampshire and Vermont. A high adult emergence each year may shorten the outbreak, but, of course, it may also increase its severity.

STATUS OF PARASITIC ENEMIES.—A striking feature of the spruce sawfly outbreak in Canada and the United States has been the almost total absence of attack by parasites, although a number of predators, such as shrews, mice and squirrels, may destroy up to 50 per cent of the hibernating cocoons. In Europe, on the other hand, where the insect has been known for over 100 years and has caused little or no damage, it has a number of valuable parasitic enemies.

In 1932 the Dominion of Canada, in cooperation with the Farnham House Laboratory in England, inaugurated an extensive program of parasite introduction. Since that time more than 20 European species of parasites have been liberated in Canada. One of the most promising of these is *Microplectron fuscipennis* Zett., a gregarious chalcidoid parasite in the cocoons of the sawfly. This species is bred easily and rapidly under laboratory conditions, and the Canadian Government has bred and liberated about 300 million of them. It has become generally established throughout most of the area colonized and shows promising powers of reproduction and spread. It is most effective when the cocoons of the host are exposed or formed under a light ground cover. Where there is deep moss and the sawfly cocoons are well covered, only small percentages have as yet been attacked. Previous to 1938 the Bureau of Entomology and Plant Quarantine received 1,800,000 of these parasites from the Canadian Parasite Laboratory, and these were liberated throughout the areas of heavy spruce sawfly infestation in New England and New York. During the 1938 season the state of Maine conducted large-scale rearing of this parasite and colonized more than 37 million of them. The New Haven forest insect laboratory of the Bureau of Entomology and Plant Quarantine, with the help of an entomologist employed by the Society for the Protection of New Hampshire Forests, reared about 5 million *Microplectron*. About $1\frac{1}{2}$ million were released in New York, 1 million in Vermont, 1 million in New Hampshire and 1 million in Maine. Fig. 3 shows the *Microplectron* liberation points in this country and the areas that were colonized by the state of Maine through 1938.

In addition to *Microplectron* the Canadian Parasite Laboratory has supplied small lots of several other species of parasites, which have been liberated in the heavy sawfly infestations of the United States. One of these, a larval parasite, *Exenterus marginatorius* (F.), has definitely proved its ability to maintain itself on the sawfly in Canada. It is, of course, too early to judge the results of these parasite liberations, but *Microplectron*, at least, has already become established at a number of points in the United States.

THE OUTLOOK FOR CONTROL.—About the only chance of successfully reducing the present sawfly outbreaks throughout the large spruce areas of Canada and the United States seems to be through nat-

ural control. A number of factors such as larval disease, starvation, and destruction of cocoons by predators are already bringing about considerable mortality, but apparently added factors are necessary. The establishment of parasites might bring about effective control. This work, however, is very slow and it may be several years before it is possible to judge whether or not the effort has been successful. The fact that the spruce sawfly prefers to feed upon the old rather than upon the new foliage may be an important factor. At least it indicates that, if the parasites can help to hold the insect at a reasonably low level of population, the trees may successfully survive a great deal of feeding.—1-6-39.

LITERATURE CITED

Balch, R. E. 1934. The European spruce sawfly. Special Circular, Entomological Branch, Ottawa, Can. 3 pp., illus.

Balch, R. E. 1936. The European spruce sawfly outbreak in 1935. Can. Ent. 68(2):23-31. Feb.

Balch, R. E. 1937. The spruce sawfly outbreak in 1936. Pulp and Paper Mag. Can. 6 pp., illus. Feb.

Balch, R. E. 1938a. Estimation of spruce sawfly hazard and need of salvage. Woodlands section, Can. Pulp and Paper Assn. Montreal. 6 pp. Jan.

Balch, R. E. 1938b. The spruce sawfly outbreak in 1937. Pulp and Paper Mag. Can. 39: 295-8. March.

MacAloney, H. J. 1936a. The European spruce sawfly in the United States. Jour. For. 34(2):125-9. Illus. Feb.

MacAloney, H. J. 1936b. The European spruce sawfly. U. S. Dept. Ag. Circ. E-379. 3 pp., illus. April Mimeographed.

MacAloney, H. J. 1936c. The European spruce sawfly. Proc. Twelfth Nat. Shade Tree Conf. 6 pp. Boston, Mass.

MacAloney, H. J. 1936d. The European spruce sawfly. Tree pest leaflets, No. 6, Mass. Forest and Park Assn. 4 pp., illus. Oct.

Matsucoccus sp.,* A Scale Insect Injurious to Certain Pines in the Northeast (Hemiptera-Homoptera)†

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Matsucoccus sp. is a scale insect of the coccid family Margarodidae closely related to the genera *Kuwania* and *Stomacoccus*. The group has certain peculiarities in the life cycle which will be discussed later. The genus *Matsucoccus* was set up by Cockerell in 1908 from material received from Japan. The taxonomic position has been given by Herbert (1919, 1921), and Morrison (1928).

The species of *Matsucoccus* under discussion feeds principally upon pitch pine (*Pinus rigida*), although shortleaf pine (*Pinus echinata*), table mountain pine (*Pinus pungens*), scrub pine (*Pinus virginiana*) and ponderosa pine (*Pinus ponderosa*) planted in the Northeast are attacked. White, jack, Scotch, Austrian, mugho and red pine are all immune. The insect will feed on red pine but cannot survive there through the first instar. The new growth on white pine is too pubescent to allow the tiny crawlers to feed, the insects never reaching the stem. On Austrian pine the crawlers reach the new growth but never feed. It appears that they become caught and die in the resinous epiderm on the new growth of that species. In the cases of jack, Scotch and mugho pines no attempt is made to feed, and all crawlers die in a comparatively short time.

Injury is most severe on pitch pine, less severe on shortleaf pine and least on table mountain pine.

Several related species of the same genus are injurious to ponderosa and other pines in the West, where some species feed on the branches and others on the needles.

DISTRIBUTION.—In the Northeast, *Matsucoccus* may be found on pitch pine over most of the range of that species, but infestations are localized. Whether this is due to a physiological condition of certain trees or to a freak of distribution remains to be determined; but it has been definitely shown that in cases where a single tree had been infested, trees to the windward were

* Now determined as *Matsucoccus gallicolus* Morrison.

† Part of a dissertation presented to the faculty of the Graduate School, Yale University, in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

subsequently not infested or were more lightly infested than those to leeward. It has been found that pitch pines in uninfested areas were heavily attacked subsequent to artificial infestation by *Matsucoccus*.

ditions. Heavy infestations are also present in other places in Massachusetts and in Connecticut, Rhode Island and New Jersey. One very light infestation has been found in New York just south of Albany, and pitch pine in many places on Long

FIG. 1.—Outline map showing by shaded areas the known distribution of *Matsucoccus* sp. in 1938, as discussed in this paper.

In some places infestations are extremely heavy. Pitch pine in Pennsylvania and on the outer half of Cape Cod in Massachusetts has been very heavily attacked. More trees have died in the infestations on Cape Cod than in any other area observed, probably because these trees are growing under unfavorable con-

Island is heavily infested. The insect has been found as far north as Madison, N.H., fig. 1. These are the limits of the writer's observations on the distribution of this species.

LIFE HISTORY AND HABITS.—*Matsucoccus* has, in some respects, a very peculiar life history. The eastern species

confines its feeding to the current year's growth, except in the case of infestation on ponderosa pine, where some feeding has been observed on the second and third internodes. The eggs hatch at about the time the new growth is from 1 to 3 inches long. The earliest hatching in the field in 1938 was recorded on April 25 at Plainville, Conn., where crawlers were emerging on the south and southwest sides of the infested trees. Hatching did not begin at Mont Alto, Pa., until April 30, when the first crawlers were found.

FIG. 2.—New growth on pitch pine from Chaplin, Conn., June 14, 1937, heavily infested with *Matsucoccus* sp. ×1.5.

Immediately after hatching the larvae migrate to the new growth, fig. 2, insert the stylets into the tender tissue and begin to feed. The crawlers lose their motility as soon as feeding has begun. Young crawlers removed from the current year's shoots 24 hours after feeding had begun were unable again to insert the stylets, and died without moving.

With continued feeding the ventral integument around the stylets begins to swell. At the same time, or soon after, there is a collapse and slight disintegration of plant tissue around the base of the stylets, and the ventral swelling of the insect sinks into the hole thus formed in the plant tissue. At this time there is also a slight swelling of the plant tissue around the outside of this hole, and a definite yellowing of the surface over the swelling. The dark yellow integument of the newly hatched crawlers gradually becomes darker until it is a dark brownish black. The swelling of the integument will take place without the formation of a hole in the plant stem, for two cases on shortleaf pine have been observed where the hole was not formed but the expansion of the venter did take place.

The slight swelling of the plant tissue continues for some time, with the continued enlargement of the hole in the stem and enlargement of the ventral swelling of the insect. At the time of the first molt, which occurs some 6 to 9 weeks after hatching, the entire body contents of the insect have sunk into the ventral swelling, fig. 3. The bulbous portion of the integument then splits laterally, and the second instar produced is a rather round, apodous, brownish-black insect. The larval integument remains in place, covering the hole in the epiderm of the twig.

The second molt appears about a month later, and with the third instar or adult stage the insect regains its appendages. When this molt occurs, the new integument is extremely soft, thin and flexible; the legs and other appendages are telescoped into the body; and the abdomen is a very much wrinkled sack. The mouth parts at this time are nonfunctional. In most instances the adult pushes aside the integument of the first-instar larva and gradually forces itself out through the tiny hole in the epiderm of the twig. But for the flexibility of the integument of the new adult this would be impossible. The female then migrates to one of the larger branches or the main trunk of the tree and pushes its way under a closely appressed bark scale, where it begins to lay eggs. The egg masses are oval, flattened pads covered with white wax threads and contain from approximately 150 to over 500 lemon-yellow eggs. Based on a count of 15 egg masses, the average number of

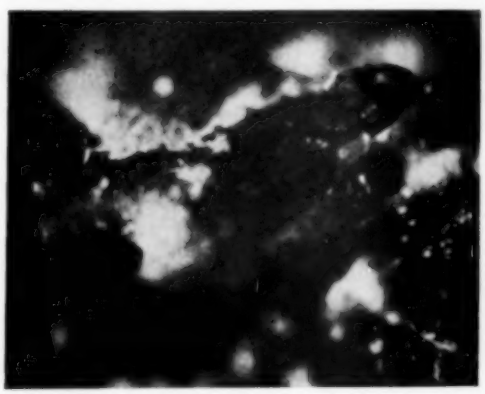

FIG. 3.—Twig surface of pitch pine with young of *Matsucoccus* sp. removed and lying on side to show ventral swelling of insect and hole in twig surface, June 22, 1937. About ×50.

eggs per female is 293.46 ± 15.06. Dissection of the reproductive organs of these females indicates that all eggs which are developed are laid, and observations show that in 80 per cent of the cases all eggs develop.

Typically, the insect overwinters in the egg stage under the bark scales on the larger branches or trunks of the trees, fig. 4, although the embryo partially develops inside the egg before cold weather sets in. During the winter of 1936–37, however, many of the females had not emerged from the holes in the twigs, and as a consequence the eggs remained inside the body of the female, but in most instances the crawlers were able to emerge in the spring. It is presumed, however, that this is an unusual situation for in the last two fall seasons the females have been able to emerge and migrate to the larger branches or trunks of the trees. Except where the female has found her way between two very tightly appressed plates of bark, the body shrinks and folds as the eggs are laid. Where she is very much flattened, the abdomen remains in that position and then not all of the eggs are deposited.

It has been stated that the average number of eggs per female is approximately 300. Little egg mortality seems to result from cold weather, a good deal of protection being no doubt offered by the bark scales under which the eggs are laid. During the winter of 1937–38, when temperatures as low as -12 degrees F. in the vicinity of Willimantic, Conn., were recorded, nearly 100 per cent of the eggs hatched when brought into the laboratory and placed in the incubator at a constant temperature of 80 degrees F. and a relative humidity of 90 per cent or above. Egg masses were removed from the bark scales on October 23 and left until December 23 and January 11 exposed in New Haven to outdoor temperatures, the lowest of which was 17 degrees F. in December and -1 degree F. in January. All the eggs hatched when exposed to room temperature and high relative humidity. It is of interest to note that in egg masses that are broken open by pulling out the strands of wax the mortality is higher than in those which remain undisturbed. This is especially true at humidities below 80 per cent.

EFFECT UPON THE PLANT TISSUE.—The first noticeable effect of insect feeding upon the plant tissue is a slight yellowing of the twig surface around the body of the insect where it is in contact with the plant tissue. If the material is cut at that time it will be found that there is a collapse of some of the plant cells just under the epiderm at the point of feeding. This

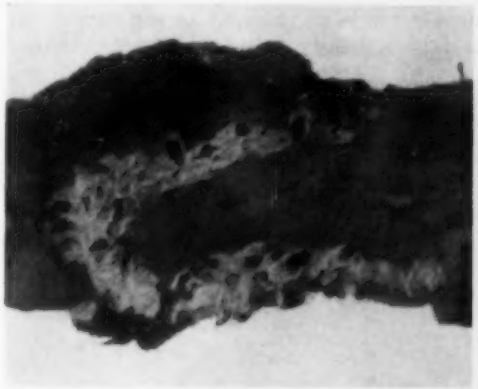

FIG. 4.—Egg masses and dead *Matsucoccus* females under bark scales from pitch pine, Plainville, Conn.

causes a slight depression in the surface of the stem at that point. At the same time there is evident an abrupt transition from the heavy-walled epiderm and collenchyma cells outside the feeding area to an area in the corresponding tissue under the insect characterized by empty and thinner-walled cells. Growth and division of the cells of the cork cambium continue outside the feeding area, whereas from this time on growth ceases under the insect. This, in addition to a slight disintegration of the epidermal and collenchyma cells immediately surrounding the stylets at the point of entrance in the plant tissue, is the immediate cause of the beginning of gall formation.

Swelling of the insect venter, which begins in from 1 to 2 weeks after hatching, continues until the first or second week in July. At that time the epiderm has broken away at the sides of the swollen venter of the insect, and proliferation of the surrounding collenchyma has extended laterally about twice the width of the swollen portion of the insect body. At about this time the insect molts, leaving the larval integument covering the hole in the surface of the twig. By the end of June the cells of the collenchyma under the swollen portion of the insect have

lignified. As growth of the insect continues this lignified area generally continues to spread laterally and in most instances toward the cambium, so that by the end of August the plant tissue surrounding many of the insects is dead and frequently infiltrated with pitch. In case of a very heavy infestation, this may occur as early as the middle of July. The dead tissue then extends all the way to the cambium, and in a heavy infestation where these

FIG. 5.—Extract injection bulbs in twig of pitch pine in greenhouse, New Haven, Conn. In this experiment swelling became apparent 4 to 5 days after injection.

dead areas coalesce death of the twig occurs at that time. This also kills the insects and precludes reproduction. Where infestation is lighter, however, death of the cortex does not progress so rapidly, and the insects develop and emerge even though the twig dies. On pitch pine, counts of infested twigs indicate that 1.2 insects per square millimeter of twig surface, fig. 2, will cause death of the twig by the middle or end of July, while 0.5 insect per square millimeter will cause death of the twig late in August or September. On shortleaf pine 0.2 insect per square millimeter will cause ultimate death of the twig.

It is of interest to note that in greenhouse grown material, where infestations were so heavy that the growing insects split open the surface of the twig, conditions of growth were such that none of the twigs died. The writer has not observed this in the field.

CAUSE OF INJURY TO TISSUE.—An attempt has been made to ascertain the cause of proliferation and eventual death of the plant tissue. Previous experiments indicated that the enzymes of the salivary glands might be the causative agent.

In the winter of 1937–38, insects removed from artificially infested pitch pines in a greenhouse were carefully dissected and the salivary glands removed and extracted in 30 per cent glycerine. An extraction time of 18 hours was used in most cases, although future experiments may show that a shorter time will suffice. Micro glass injection bulbs were made, the salivary extract drawn up into the neck of the tube by capillary action, and the tip of the tube inserted into the collenchyma of the new growth of uninfested trees, fig. 5. Extract from the salivary glands of from 6 to 12 insects was used in most cases. Check injections were made at the same time, plain 30 per cent glycerine or the empty injection bulbs being used. The top of the bulb being closed, an increase of air temperature in the greenhouse caused an expansion of air in the bulb and forced the extract into the plant tissue. Cooling of the air caused a contraction and sucking of the liquid back up into the neck of the tube, thus to some extent simulating the action of the insect forcing salivary juice down into the plant and sucking up food, the difference being that there is a continual renewal of the salivary juice in the case of the insect while there is not in the case of the micro bulb. A large number of such injections were made with very encouraging results.

On May 20, 1938, the salivary glands from 6 second-instar insects were extracted for 18 hours. On May 21, five bulbs containing the extract were placed on new growth of a tree in the greenhouse, and at the same time check bulbs were inserted in another twig on the same tree. On May 24 three of the five extract injections made on May 21 appeared to be causing the typical yellowing of the surface of the plant tissue around the point of injection, not only laterally, where it might be caused by compression of the cells from insertion of the bulb, but also vertically on the twig. On May 26 all five of the injection bulbs showed the same injury while none had appeared on any of the checks. On June 1, none of the checks showed any injury whereas all the extract injections showed yellowing and a slight swelling.

One June 4 several injections were made from an extract of the glands of only two

late second-instar insects. On June 8 all the extract injections showed injury and slight swelling while neither was apparent on the checks. From this it appeared that there is a greater effect from the feeding of the older than from the younger instar of the insect. Further experiments with extract from a similar instar made on trees in the field produced the same results.

Injury did not appear around any of the check bulbs until in July, and that was but a very narrow ring of dead tissue immediately around some of the glass tubes. Others showed no injury at all. There is nearly always a flow of pitch around the check bulbs, but this has never been known to occur on extract injections.

ECONOMIC IMPORTANCE.—Where a population of the insect has built up over a period of years, damage to the trees may be considerable. In some plantations and in some areas of natural pitch pine reproduction in Pennsylvania, the new growth and subsequent latent bud growth have been killed in successive seasons with the

FIG. 6.—Crooked trunks and bent leaders of pitch pine at Mont Alto, Pa.

result that trees have died or are in such poor condition that they will never produce timber. This statement applies to all crown classes.

In one sample plot in a 19-year old pitch pine plantation at Mont Alto, Pa., 43 per cent of all the trees on the plot lost their leaders in 1938. Of the 23 dominants on the plot, 3 trees, 13 per cent, had leaders killed; 57.5 per cent of the codominants had leaders killed back in 1938, as did 50 per cent of the intermediates and 37.5 per cent of those classed as suppressed. In the same plantation there is evidence, from crooked trunks, fig. 6, that the insect has been active in killing leaders

FIG. 7.—Heavily infested pitch pine showing dead shoots killed in 1937 by *Matsucoccus*, June, 1938, Mount Union, Pa. Note that nearly all of the 1937 shoots have been killed.

on trees in all crown classes for at least 8 years. In another plot, in natural reproduction of shortleaf pine, at Mont Alto, 63.6 per cent of the trees attacked by the insect in 1938 had leaders killed.

Data from a very heavily infested pitch pine plot near Mount Union, Pa., show that 74.2 per cent of the trees lost leaders in 1938, fig. 7. This plot is so heavily infested that the trees have practically ceased to grow. Many of them have no new growth except that put out as latent shoots, and in 1938 most of those also were killed.

Apparently these infestations began to be serious about 8 or 9 years ago. Trees from both Mont Alto and Mount Union that had crooked stems have been dissected, and it is possible to trace evidence of heavy attack back 8 to 9 years by uncovering pitch-killed insects in the wood. This would point to a first serious attack by the insect during the serious drought of 1930.

In the Northeast the area most affected is probably the outer end of Cape Cod, Mass., where in one place it was observed that over 50 per cent of the pitch pines had been killed. Many other instances have been observed in Massachusetts, Rhode Island and Connecticut where trees, particularly ornamentals, were in very poor condition or were dead. The Washington office has reports of a similar condition on Long Island.

The insect attacks all age classes from 3-year old seedlings to mature trees but is most destructive on material from 10 to 30 feet in height. A fairly heavy infestation seems to have little effect on larger trees, because, although a comparatively large number of current shoots are killed, those living are in far higher ratio to those dead than is the case among young trees.

NATURAL ENEMIES AND CONTROL.—No natural enemies of the mature insect have been observed, although one thrips, one hemipterous insect and larvae of a clerid have been found feeding on the eggs. Preliminary spraying experiments indicate that lime sulfur will probably be effective in control on ornamentals.—1-6-39.

LITERATURE CITED

Herbert, F. B. 1919. A new species of *Matsucoccus* from pines in California (Hemiptera-Homoptera). Proc. Ent. Soc. Wash. **21**: 157–61. Illus. Oct.

Herbert, F. B. 1921. The genus *Matsucoccus* with a new species (Hemiptera-Homoptera). Proc. Ent. Soc. Wash. **23**: 15–22. Illus. Jan.

Morrison, Harold. 1928. A classification of the higher groups and genera of the coccid family Margarodidae. U. S. Dept. Ag. Tech. Bul. **52**. 240 pp., illus. July.

Tests With Various Elm-Wood Traps for Bark Beetles

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In studies of the Dutch elm disease fungus, *Ceratostomella ulmi* (Schwarz) Buisman, cognizance must be taken of its two principal insect vectors in the United States, *Scolytus multistriatus* Marsham and *Hylurgopinus rufipes* (Eich.), and the possibility of their control by traps. It has been noted through field observations that for the most part these two species of bark beetles are found breeding in recently cut or rapidly dying elm wood. With this fact in mind various types of elm-wood traps were compared as to their relative attractiveness to these particular insects. The possibility of the use of traps as an actual means of control for these bark beetles is worthy of further investigation.

EXPERIMENTAL METHODS, 1935 AND 1936.—The first series of elm-wood traps was cut and placed in the field during the last week of May, 1935. This series of traps consisted of the following types:

1. Two small elm trees with a diameter, breast high, of 6 to 7 inches, cut off 6 inches above ground, and the butt ends placed on their respective stumps. One of these trees was felled so as to be exposed to the greatest possible amount of sunlight and the other was felled in deep shade.

2. Two small elm trees with a diameter, breast high, of 6 to 7 inches, killed by the injection of a strong solution of sodium arsenite. This injection was made by pouring 1 ounce of the poison into each of four auger holes drilled in the trunk at breast height. One tree was located at the edge of a clearing and the other in a more shaded area.

3. Four medium-sized elm limbs cut with a saw to the point at which they broke but remained hanging. The butt ends of these limbs were located at 15, 25, 35 and 45 feet above ground. All limbs were exposed to intermittent periods of sunlight.

4. Twenty-four recently cut elm logs ranging in length from 32 to 42 inches and

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in diameter from 3 to 6 inches. The growth rate, as determined by a ring count, varied from very slow to very rapid. These logs were placed as follows:

a. Four logs stood on end in a clearing. Laths were used to support these logs.
b. Four logs stood on end in the shade.
c. Four logs laid on the ground in a clearing.
d. Four logs laid on the ground in the shade.
e. Four pairs of logs, each pair tied together and suspended in an elm tree by means of a rope. The heights of the centers of the pairs above ground were 18, 20, 22 and 25 feet.

All the traps included in this first series were exposed in one small wooded area.

The second series of traps was cut and placed in the field during the third week of June, 1935. This series differed from the first in that only one tree killed by sodium arsenite was used and the severed limbs and suspended logs were omitted. This series of traps was replicated in four widely separated woodland areas.

The third series of traps included all the types used in the second series and was cut and placed in the field during the last week of June, 1935. This series was placed in only one location.

The fourth series of traps was cut and placed in the field during the first week of August, 1935. This series consisted of only one felled tree, one tree killed by sodium arsenite and one tree girdled one-half to 1 inch into the xylem. These traps were duplicated in two areas.

The fifth and last series of 1935 was cut and placed in the field during the second week of September. The traps included in this series were of the same type as those in the fourth series. This series was placed in only one area.

Both *Scolytus multistriatus* and *Hylurgopinus rufipes* were known to be present in all the areas used for these five series of traps. The predominant tree species of all these areas, except one of the four used for the second series of traps, was *Ulmus americana* L. In the one exceptional area the predominant tree species was *U. fulva* Michaux.

All traps remained in the field from 6 to 7 weeks. This period allowed sufficient time for maximum bark beetle attack but was not sufficient for the progeny to develop to adults. The traps were examined about twice a week, the felled trees offering the best opportunities for observations. It was noted that the two bark beetles were most active early in the afternoon, that *Scolytus multistriatus* preferred trees exposed to sunlight, and that *Hylurgopinus rufipes* preferred the shaded trees, as was noted also by Martin (1938).

When the traps were removed from the field the felled trees and those treated with sodium arsenite were cut into short sections of uniform length, and every other section was placed in rearing containers which were kept at room temperature. The remainder of these traps and all the other traps were debarked, counts were made of the bark beetle maternal tunnels, the number of cerambycid larvae and the number of buprestid larvae, and a record was made of other types of insect attack. The rearing containers were examined daily, and a record was kept of the principal insects emerging.

RESULTS.—It will be noted that not all the types of traps used in the first series were duplicated in the later series. For this reason only the results of the first series are included in table 1. Table 2 includes the results of the later series as well as of those traps of the first series which were duplicated in some or all of the later series. The traps cut and exposed in September, 1935, and comprising the fifth series had no infestation and are therefore not included in these tables. The three girdled elms also were omitted because they did not die and were therefore not attractive to the bark beetles.

The results of rearing the broods in one-half of the sections of the felled trees and of those treated with sodium arsenite showed that larvae of the following Coleoptera, in the order of their abundance, occurred in this bark and wood: (1) *Scolytus multistriatus* Marsham, (2) *Hylurgopinus rufipes* (Eich.), (3) *Saperda tridentata* Oliv., (4) *Magdalis armicollis* Say, (5) *Magdalis barbita* Say, (6) *Neoclytus acuminatus* (F.), (7) *Xylotrechus colonus* (F.), (8) *Chrysobothris femorata* (Oliv.), (9) *Anthaxia viridifrons* Gory, (10) *Laemophloeus fasciatus* Melsh., and (11) *Molamba fasciata* (Say). Small numbers of other species were reared but they were not recorded.

EXPERIMENTAL METHODS, 1937 AND 1938.—In 1937 the experimental work

Table 1.—Results of elm-wood traps in first series, 1935.

Description and Location of Trap	Total Bark Area, Square Inches	Maternal Galleries Per 100 Square Inches of Bark Area	
		Scolytus multistriatus	*Hylurgopinus rufipes*
Felled elm tree in sun	2,859*	9.79	6.54
Felled elm tree in shade	1,561*	0.00	13.58
Elm trees killed with sodium arsenite	4,812*	0.21	5.63
Severed and hanging elm limbs†	4,524	0.51	0.42
Suspended elm logs†	3,984	0.00	1.28
Elm logs stood in sun	7,545	1.64	0.91
Elm logs laid in sun on ground	7,019	0.80	0.28
Elm logs stood in shade	7,014	0.96	1.45
Elm logs laid in shade on ground	7,539	0.88	0.45

* Does not include the sections used for rearing purposes.
† No significant difference was found among the various heights.

with elm-wood traps consisted principally of observing the attractiveness of felled elms and chemically treated elms to *Scolytus multistriatus* and *Hylurgopinus rufipes*. These observations were made in conjunction with a large experiment on the introduction of chemicals into living elm trees. It was noted that when certain chemicals were applied to living elm trees those trees become more favorable for bark beetle attack than felled trees.

In 1938 it was decided to check these observations further. For this purpose several types of elm-wood traps were duplicated in two widely separated areas during the months of February, May and July. Three elm trees approximately 6, 10 and 15 inches in diameter, breast high, were used for each type of trap, each month, and in both locations; a total of 18 trees for each treatment. The following types of traps were included in these studies:

1. Living elm trees felled, with the butt ends placed on their respective stumps.

2. Living elm trees girdled, breast high, 1 inch into the xylem.

3. Living elm trees treated by means of a chisel girdle and a water-tight rubberized collar described by Lantz (1938) with the following chemicals in water solutions:

   a. Ferrous sulfate at the rate of 75 cubic centimeters per inch diameter (30 grams of dry ferrous sulfate in 75 cubic centimeters of solution).
   b. Copper sulfate at the rate of 30 cubic centimeters per inch diameter (1 gram of dry copper sulfate in 30 cubic centimeters of solution).
   c. Sodium chlorate at rates of 30 and 60 cubic centimeters per inch diameter (5 grams of dry sodium chlorate in 30 cubic centimeters of solution).

4. Living elm trees treated with dry copper sulfate at the rate of 120 grams per diameter inch by the method described by Liming (1937).

These traps remained in the field from 5 to 7 weeks after they became suitable for bark beetle attack.

Table 2.—Results of elm-wood traps in series 1 to 4, inclusive, 1935.

Description of Trap	Bark Area, Square Inches	Maternal Galleries Per 100 Square Inches of Bark Area	
		Scolytus multistriatus	*Hylurgopinus rufipes*
Felled elm trees in shade	12,177*	2.93	1.78
Felled elm trees in sun	26,724*	2.54	0.70
Elm trees killed with sodium arsenite	24,621*	0.96	1.15
Elm logs laid in shade†	7,539	0.88	0.45
Elm logs stood in shade†	7,014	0.96	1.45
Elm logs laid in sun†	7,019	0.80	0.28
Elm logs stood in sun†	7,545	1.64	0.91

* Does not include the sections used for rearing purposes.
† These traps were not included in the fourth (or August) series.

Table 3.—Results of elm-wood traps, 1938.

Description of Trap	Total Bark Area, Square Feet*	Maternal Galleries Per Square Foot of Bark Area		Proportion of Bark Area Attractive, Per Cent†
		Scolytus multistriatus	*Hylurgopinus rufipes*	
Elm trees treated with sodium chlorate, 10 grams per inch DBH‡	1,200	7.42	1.20	100.0
Elm trees treated with sodium chlorate, 5 grams per inch DBH	1,301	5.01	1.34	90.3
Elm trees felled and butts placed on stumps 2 feet in height	1,618	4.20	2.74	100.0
Elm trees treated with dry copper sulfate, 120 grams per inch DBH	1,689	4.55	0.46	84.0
Elm trees treated with ferrous sulfate, 30 grams per inch DBH	1,811	5.14	0.15	68.0
Elm trees treated with liquid copper sulfate, 1 gram per inch DBH	1,767	0.58	0.15	14.4
Elm trees girdled at breast height 1 inch into xylem	1,677	0.31	0.33	32.3

* This column includes estimates of the bark area of trap trees too green for bark beetle attack and which were therefore not felled.
† This column refers only to the bark area on the trees that were killed and subsequently felled.
‡ DBH, diameter at breast height.

When the traps were examined each tree was cut into 4-foot sections, each section measured for bark area and debarked, and a count made of the maternal galleries of *Scolytus multistriatus* and *Hylurgopinus rufipes*. In those instances where the trees remained living and consequently unsuitable for bark beetle attack they were not felled, but an estimate was made of their total bark area. These estimates were based on measurements of hundreds of trees of the same sizes.

RESULTS.—The results of the elm-wood traps of 1938 for *Scolytus multistriatus* and *Hylurgopinus rufipes* are included in table 3.

The first examination of the 1938 traps was made early in July, and these preliminary results showed that elm trees treated with a water solution of sodium chlorate were considerably more attractive to the two bark beetles than any of the other traps. For this reason it was decided further to compare trees treated with sodium chlorate with felled trees in two large field plots.

The two plots selected for this comparative study of felled trees and trees treated with sodium chlorate were predominantly *Ulmus americana*. The first plot (plot A) of about 8 acres had 871 standing elm trees averaging 7.7 ± 0.88 inches in diameter at breast height. The second plot (plot B) of about 3.7 acres had 550 standing elm trees averaging 6.5 ± 0.125 inches in diameter at breast height.

Seventeen (1.95 per cent) of the standing elm trees in plot A were felled on July 18, 1935, about the time of emergence of

Table 4.—Results from the use of felled and sodium chlorate–treated elm-tree traps, 1938.

Plot and Treatment	Number of Trees Treated	Average Diameter (Breast High), Inches	Total Number of 6-Foot Sections	Total Bark Area, Square Feet	Galleries of *Scolytus multistriatus* Per Square Foot of Bark	
					Average Number	Difference
Plot A						
Felled	17	7.7 ± 0.442*	117	925	5.11 ± 0.562	
Sodium chlorate†	17	7.7 ± 0.048	114	953	8.31 ± 0.653	+3.20‡
Plot B						
Felled	21	6.5 ± 0.185	106	698	13.50 ± 0.966	
Sodium chlorate†	21	6.7 ± 0.262	115	781	19.87 ± 1.191	+6.37‡

* The figures following the ± sign are standard errors.
† Applied in water solution at the rate of 10 grams of the dry sodium chlorate per inch diameter.
‡ According to R. A. Fisher's table of "t," this difference is highly significant.

the second brood of *Scolytus multistriatus*. The butt ends were placed on the top of stumps, 2 feet above the ground. On the same day 17 other standing trees were treated (Lantz 1938) with a water solution of sodium chlorate at the rate of 10 grams of the dry salt per inch diameter. Both the felled and treated trees averaged 7.7 inches in diameter at breast height and were distributed on the basis of the distribution of the standing elm trees.

Twenty-one (3.82 per cent) of the standing elm trees in plot B were felled and 21 other trees were chemically treated as in plot A on July 19, 1938. The felled trees averaged 6.5 inches and the treated trees averaged 6.7 inches in diameter at breast height. Both types of traps were distributed as in plot A.

At the end of the flight period of *Scolytus multistriatus* all trees were cut into 6-foot sections, and the number of maternal galleries was counted for each section. No galleries of *Hylurgopinus rufipes* were found in the traps.

The results of plots A and B are included in table 4.

SUMMARY.—The first tests with elmwood traps for two bark beetles, *Scolytus multistriatus* Marsham and *Hylurgopinus rufipes* (Eich.), were made in 1935. These tests included (a) felled trees, (b) chemically killed trees, (c) girdled trees and (d) elm logs laid and stood on the ground. The felled trees were the most attractive to the beetles.

In 1937 it was observed that elm trees killed with certain previously untried chemicals were more attractive to bark beetles than were felled trees.

The studies of 1938 included comparative tests with felled trees, girdled trees and trees treated with sodium chlorate, ferrous sulfate and copper sulfate. These tests indicated that trees treated with sodium chlorate were the most attractive. Further studies conducted in two large field plots showed that elms treated with sodium chlorate were significantly more attractive than were felled elms.—1-6-39.

LITERATURE CITED

Lantz, A. E. 1938. An efficient method for introducing liquid chemicals into living trees. U. S. Dept. Ag., Bur. Ent. and Plant Quar., Mimeographed Circular **E-434**. 4 pp., illus. May.

Liming, O. N. 1937. U. S. Dept. Ag. Plant Disease Reporter. Supplement 99:18–25. May.

Martin, C. H. 1938. Effect of sunlight and location of logs on the beetle infestations of elm logs. Bul. Brooklyn Ent. Soc. **33**(4):195–201. Illus. October.

Control of Borers in Newly Set Shade Trees

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A program of establishing shade trees along Illinois highways provided an excellent opportunity for the study of the borer problem under a variety of conditions. The study was carried on in cooperation with the Illinois Division of Highways. Each year blocks of newly set trees were set aside at three locations for these experiments. Trees were tagged, treated and scored through the first and second seasons after planting in 1935, 1936, 1937 and 1938. This paper reports a detailed study on 1,074 trees. Figures show in percentage the live and dead trees, trees attacked above the wrapping, trees attacked on the main trunk either wrapped or not wrapped and trees identified as killed by borer attack. The percentage of dead trees may include some trees killed by borers and removed before records were made as to cause of death.

RESPONSIBLE INSECT SPECIES.—During the study, rearings were made to determine the species involved. The flatheaded apple tree borer, *Chrysobothris femorata* (Oliv.), accounted for nearly all the losses except a 1.2 per cent loss of all trees from the red-headed ash borer, *Neoclytus acuminatus* (F.). The latter borer attacked all tree species, but preferred ash, hackberry, maple, oak, elm, in about the order named. Wrapping apparently has no effect in its control. In a few cases, hackberry trees were killed by *Agrilus falfax* (Say).

TREE SPECIES.—Trees in tests were taken as they occurred as a mixed planting, table 1. Elm was most abundant,

Table 1.—All tree species summarized in percentage for all treatments. All tests are on newly planted trees. To minimize factors of resistance, maple, elm and oak, and elm are totaled separately. Control trees were not wrapped.

Species	Wrapped First Year						Wrapped First and Second Year						Exposed Second Year					
				Injury						Injury						Injury		
	Number of Trees	Living	Dead	Above Wrap	Trunk	Killed by Borer	Number of Trees	Living	Dead	Above Wrap	Trunk	Killed by Borer	Number of Trees	Living	Dead	Above Wrap	Trunk	Killed by Borer
Ash	55	87.3	12.7	3.6	3.6	1.8	19	94.7	5.3	0.0	0.0	0.0	20	100.0	0.0	0.0	10.0	0.0
Elm	258	89.1	10.9	44.9	1.2	0.4	118	100.0	0.0	16.1	6.8	0.0	107	86.9	13.1	36.5	75.7	13.1
Maple	98	57.7	42.3	28.6	13.2	7.1	27	92.6	7.4	7.4	25.9	7.4	11	81.8	18.2	9.1	63.6	18.2
Oak	119	79.8	20.2	10.1	0.0	0.0	56	96.4	3.6	3.6	8.9	3.6	34	97.1	2.9	8.8	52.9	2.9
Hackberry	38	97.4	2.6	2.6	0.0	0.0	11	100.0	0.0	0.0	0.0	0.0	17	88.2	11.8	5.9	11.8	11.8
Linden	36	63.9	36.1	30.5	11.1	0.0	11	100.0	0.0	18.2	45.4	0.0	6	83.3	16.6	16.6	16.6	16.6
Sycamore	4	75.0	25.0	25.0	0.0	0.0	—	—	—	—	—	—	2	100.0	0.0	0.0	0.0	0.0
Total W	608	80.9	19.1	28.1	3.5	1.5	242	97.9	2.1	10.3	10.3	1.7	197	89.8	10.2	22.8	56.3	10.2
Total C	88	55.7	44.3	35.2	56.8	31.8	—	—	—	—	—	—	45	82.2	17.8	35.5	51.1	17.8
Maple W Elm W Oak W	475	80.4	19.6	32.8	3.4	1.7	201	98.0	2.0	11.4	9.9	2.0	152	88.8	11.2	28.3	69.7	11.2
Maple C Elm C Oak C	69	52.2	47.8	43.5	69.6	37.6	—	—	—	—	—	—	36	80.6	19.4	38.9	55.6	19.4
Elm W	258	89.1	10.9	44.9	1.2	0.4	118	100.0	0.0	16.1	6.8	0.0	107	88.8	11.2	36.5	75.7	11.2
Elm C	39	53.8	46.2	64.1	84.6	43.5	—	—	—	—	—	—	22	68.1	31.9	54.5	68.1	31.9

C = Control.
W = Wrapped.

Table 2.—All treatments summarized in percentage for all tree species. Tests include years 1935, 1936, 1937, 1938 at nine locations in Illinois. All tests except crepe spiral start with newly planted trees. Crepe spiral tests include trees wrapped by Division of Highways, scored at end of growing season, and do not include trees removed for various causes during the growing season. Control trees were not wrapped.

Treatments	Wrapped First Year						Wrapped First and Second Year						Exposed Second Year					
				Injury						Injury						Injury		
	Number of Trees	Living	Dead	Above Wrap	Trunk	Killed by Borer	Number of Trees	Living	Dead	Above Wrap	Trunk	Killed by Borer	Number of Trees	Living	Dead	Above Wrap	Trunk	Killed by Borer
Wrapping paper	84	80.9	19.0	21.4	0.0	0.0	40	100.0	0.0	2.5	2.5	0.0	25	92.0	8.0	16.0	60.0	8.0
Newspaper	87	75.8	24.2	19.5	2.3	2.3	38	100.0	0.0	13.1	7.9	0.0	25	88.0	12.0	12.0	28.0	12.0
Burlap	117	76.9	23.1	23.9	1.8	0.8	43	100.0	0.0	4.6	16.2	0.0	36	88.8	11.2	8.3	44.4	11.2
Muslin	34	94.2	5.8	35.3	2.9	0.0	18	88.8	11.2	22.2	16.6	11.2	9	100.0	0.0	22.2	55.5	0.0
Sisal spiral	143	70.6	29.4	18.2	4.2	0.7	47	93.6	6.4	6.4	17.0	4.2	40	92.5	7.5	7.5	67.5	7.5
Crepe spiral	142	94.3	5.7	45.8	10.5	3.5	61	100.0	0.0	14.7	1.6	0.0	51	88.2	11.8	58.8	84.3	11.8
Total	606	81.0	19.0	27.4	4.3	1.5	247	97.9	2.1	9.7	9.3	1.6	186	90.3	9.7	24.2	60.7	9.7
Naphthalene repellent	30	63.3	36.7	50.0	73.3	16.6	—	—	—	—	—	—	15	53.3	46.7	60.0	86.6	46.7
Whitewash	29	62.1	37.9	34.5	51.7	10.3	—	—	—	—	—	—	18	83.3	16.7	38.8	72.2	11.2
*B.L. 50**	27	74.1	25.9	29.6	40.0	3.7	—	—	—	—	—	—	18	100.0	0.0	5.5	5.5	0.0
Dendrol and P.D.B.†	30	60.0	40.0	13.3	33.3	16.6	—	—	—	—	—	—	14	85.7	14.3	14.2	28.4	14.3
Total	116	64.6	35.4	31.9	50.0	12.0	—	—	—	—	—	—	65	81.5	18.5	29.2	47.7	16.9
Control	86	55.7	44.3	35.2	56.8	31.8	—	—	—	—	—	—	45	82.2	17.8	35.5	51.1	17.8

* *Black Leaf 50.*
† *Dendrol* and paradichlorobenzene.

followed by oak, maple, ash, hackberry, linden and sycamore. Of these, hard maple proved the most difficult tree to establish and keep free of borers. The order of survival for the wrapped trees for the first year was hackberry, elm, ash, oak, sycamore, linden and maple. Of these, ash and hackberry were seldom attacked by the flat-headed apple tree borer. Oak was moderately invaded and frequently was killed by a few borers girdling the base of the tree. Elm was heavily attacked but vigorous growth overcame injury as great as 50 per cent of the trunk bark area.

Trees given the wrapping treatments were wrapped the first growing season. In October, half of the trees were unwrapped and scored. At the end of the second growing season, those trees in the half wrapped 2 years were unwrapped and scored, and those in the group unwrapped the first year were rescored. Data in the tables summarize the results under these three groupings, wrapped first year, wrapped first and second years, wrapped first year and exposed second year.

CONTROL THROUGH WRAPPING.—Experiments proved that wrapping of the trunks for the first 2 growing seasons to be the most practical control for the flat-headed apple tree borer. The efficiency of the several wrapping treatments is shown in table 2. Wrappings made up of large sheets were superior to those of narrow papers wrapped spirally and forming, necessarily, many crevices. The order of efficiency of the several treatments was wrapping paper, burlap, newspaper, muslin and spiral paper. The 2-inch, spirally wound, crepe paper treatment should not be compared directly with the other treatments as it represents only a score of trees taken at the end of the growing season.

SECOND SEASON OF WRAPPING.—A comparison between trees wrapped or exposed for the second season shows that only 9.3 per cent of the wrapped trunks were damaged while 60.7 per cent of the unwrapped trunks were injured. Although not shown in the tables, data taken on the trees after their third season indicate that trees surviving two seasons are established and seldom are injured by the borer when growing normally. Where injury occurred after 2 years it could generally be traced to damage by fire, mowing machinery or accident.

FAILURE OF OTHER METHODS.—Two repellent treatments failed to control borers. One consisted of a long recommended mixture of soap and naphthalene, and the other a whitewash formula containing sulfur.

Rather poor results were obtained with two treatments applied to kill the established young borers. *Black Leaf 50* (Tobacco By-Products Co., Louisville, Ky.) was applied as a paint to the trunk. *Dendrol*, a miscible oil (Standard Oil Co., Indiana) plus paradichlorobenzene, 2 pounds per gallon of oil, was diluted with an equal volume of water and applied as a paint or spray. Neither mixture caused injury to the tree trunks.

PREVENTION OF TOP INJURY.—About 20 per cent of all trees were attacked in the crotches and trunk above the wrappings. Most of the injury could be avoided by extending the wrappings up into the shaded portions of the trunks. Trees that were allowed to develop sucker growth on the exposed portions of the trunk were less subject to attack.

SHORT PERIOD OF ATTACK.—To determine the period of attack, trunks were exposed for 1 month. As shown in table 3, most of the damage was found to start in June and July, although in some years eggs are laid during May or August. Protecting the trunks through May to September was adequate in Illinois. Eggs laid in one year hatched and emerged as adult beetles the next year. The borer passed the winter as a partially to full-grown larva under the outer bark or deep in the heartwood.

Table 3.—The establishment of borers in all tree species where the trunks were exposed without wrappings for one month.

MONTH OF EXPOSURE	MAY	JUNE	JULY	AUGUST	TOTAL
Number of trees	60	69	69	68	266
Percentage of trunks injured	3.3	20.7	33.3	11.7	17.8
Control	88 trees exposed all season				31.8

WRAPPING MATERIALS.—In the course of experiments the different wrapping materials were studied for borer protection, cost, ease of application, permanence and appearance. Regular 40-pound wrapping paper in 24-inch rolls was found superior to all other materials for wrapping purposes. A length of this paper

equal to the trunk height could be neatly applied in 1 or 2 minutes by two men. Loops of binder twine at 3- to 4-inch intervals held the wrapping secure for 2 years. Newspaper was very satisfactory but difficult to handle without tearing. Burlap was very satisfactory but difficult to remove. Muslin was discarded after 1 year because of higher cost. A white and black reinforced sisal Kraft lightproof paper in 4-inch width was applied as a spiral wrap. The white grade was superior to black, although both were fairly satisfactory. They are not as permanent as wrapping paper, subject to breakage after one year and not as efficient in borer protection. The spiral applications are often too tight on smooth-barked trees and difficult to hold in position on rough trees. The 2-inch crepe paper applied as a spiral wrap by the Illinois Division of Highways was inferior to the experimental spiral for similar reasons and the very narrow width. All paper wrappings were found to have disintegrated by the end of the second growing period. If any wrappings remain at that time they should be removed.

SUMMARY.—In newly established plantings of shade trees, the flatheaded apple tree borer, *Chrysobothris femorata*, (Oliv.), vigorously attacked all tree species present except hackberry and ash. Wrapping with paper or burlap of that portion of the trunk not shaded by leaves gave excellent protection and reduced borer injury. Wrapping paper was superior to all other materials tested for borer protection, permanence and low cost. Newly set trees should be wrapped for the first two growing seasons after they are set.—1-20-39.

Some Effects of Acid Arsenate of Lead Used Against the Termite, *Reticulitermes flavipes* (Kollar)*

THOMAS J. HEADLEE and D. MANLEY JOBBINS, *New Jersey Agricultural Experiment Station, New Brunswick*

In most of the works on the control of subterranean termites arsenicals command a very considerable amount of attention but rarely is arsenate of lead mentioned as one of the arsenicals tested. This appears to be the condition notwithstanding the fact that the acid arsenate of lead has been shown to be the outstanding material for control of Japanese beetle and other grubs in the soil. It is a well known fact that when sufficient arsenate of lead is incorporated in the soil in amounts still within the tolerance of grasses, the true ants commonly found in such areas are eliminated. It is also a well known fact that acid arsenate of lead is extremely persistent in the soils in which it has been used. Such soils as Lakewood Sand lose very little of the arsenate of lead charge within a period of 10 years, even when fully exposed to outdoor weathering effects. Furthermore, acid arsenate of lead moves in the soil up or down to a very limited extent. With such facts in mind, it seems truly strange that arsenate of lead has not received extensive attention as an agent for eliminating termites from certain soils.

EXPERIMENTAL WORK.—In the early season of 1937 opportunity arose to make some tests in the Lakewood Sand series, near Breton Woods, Ocean County, N.J.

The pine region of New Jersey was chosen as the place for the experiments because of the extreme abundance of *Reticulitermes flavipes* (Kollar) throughout. Repeated studies of the prevalence of the termite in this area were made, and any log or stump not so rotten as to be crushable with the fingers and not so recently cut as still to be loaded with resins seemed to be infested. In areas over which, within less than 2 years, heavy forest fires had swept and in which the tree trunks and the logs on the ground were black, the termites were always present in suitable timber.

Six plots were selected in a pine wood area such as that shown in fig. 1. Each plot was 8 inches deep, 16 inches wide and 4 feet long. Soil was removed from each plot. Arsenate of lead was sifted over the bottom and sides of the trench and a part of the earth replaced. This earth was then worked over with a garden

* Paper of the Journal Series, New Jersey Agricultural Experiment Station, Department of Entomology.

trowel. More arsenate of lead was then sifted in and again worked over. This procedure was continued with 1 to one-half inch layers until the trench was completely refilled. In each plot were placed two air-dried white pine boards 30 inches long, 4½ inches wide and three-quarters inch thick. These boards were buried horizontally 2 inches beneath the surface of the plots and covered over with the soil used in filling the trenches. The experiment was set in June, 1937.

FIG. 1.—Location where termite tests were made.

RESULTS.—Regular checking showed that by August 27, 1937, termite workers were active in all checks. Throughout October, activity seemed to increase. On October 27, 1937, termites had worked entirely through one of the check boards and were cutting longitudinal galleries from end to end.

In 5 months of exposure not a single sign of termite attack appeared on any of the boards in the plots treated with arsenate of lead. Unprotected boards and fallen limbs in contact with the ground in this location were attacked in a few weeks. One of the boards in each of the treated plots was left undisturbed until June, 1938, and at the time of removal none of these boards showed any evidence of attack by termites.

Table 1 shows that protection given by the minimum treatment with arsenate of lead was entirely complete for about 1 year. This minimum treatment is about one-half the dose which is considered

Table 1.—Concentration of acid arsenate of lead used in test plots at Breton Woods.

PLOT NO.	POUNDS PER CUBIC FOOT	EQUIVALENT POUNDS PER ACRE APPLICATION 4 INCHES DEEP
1	0.05	726
2	0.10	1,452
3	No treatment	
4	0.20	2,904
5	0.40	5,808
6	No treatment	

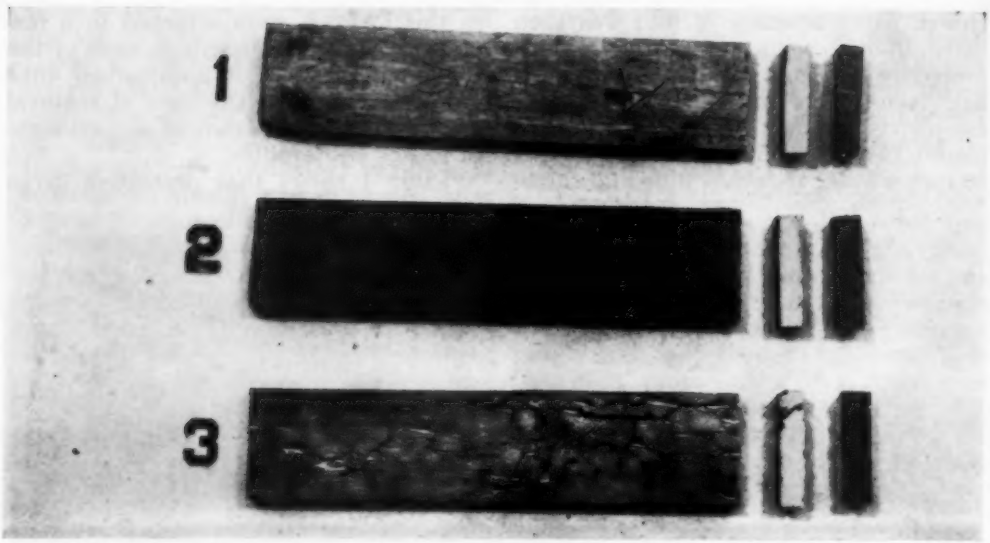

FIG. 2.—Pine boards exposed in soil to termite work; 1, placed in treated soil and removed 6 months later; 2, placed in treated soil and removed 1 year later; 3, placed in untreated soil and infested in 6 weeks.

complete treatment for Japanese beetle grubs. It is obvious that the minimum lethal dosage lies somewhere below the lowest treatment.

DISCUSSION AND CONCLUSIONS.—*Reticulitermes flavipes* (Kollar) is apparently prevented from working timbers surrounded by soil treated with acid arsenate of lead. The cost of making such a treatment on soil beneath the structure to be erected is comparatively very small. The persistence of such a treatment is extraordinarily long, even when fully exposed to weathering agencies, and when not so exposed it is probably much longer. The results of this study seem to indicate that we may have been overlooking a cheap and practicable method for control of the common termite, *Reticulitermes flavipes*.—1-9-39.

The Relation of Nutritional Levels to the Growth of Populations of *Tribolium confusum* Duv.

II. Egg Production in Patent Flour and in Patent Flour Supplemented With Yeast

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In the first paper of this series (Bushnell 1938), it was pointed out that in the development of populations of the confused flour beetle, *Tribolium confusum* Duv., the number of young larvae present was significantly higher in a yeast-supplemented cornmeal diet than in a plain cornmeal diet. It was suggested that this abundance of young larvae may have been due to an enhanced productivity of the females fed on the yeast-supplemented diet. It is the purpose of the study reported here to test this suggestion by making complete egg-production records of beetles living on patent flour and on yeast-supplemented patent flour.

METHODS.—The beetles to be tested were reared on a cornmeal patent flour medium to the pupal stage, when the sexes were sorted. On the day after emergence of the adults, single pairs were placed in 2-ounce salve tins along with 10 ounces of food medium. The food consisted of plain patent flour or 8 ounces

of patent flour thoroughly mixed and sifted with 2 ounces of finely ground brewers' yeast. The salve tins were ventilated through a three-quarter-inch disk of 60-mesh wire cloth soldered into the cover and were kept in an incubator at approximately 30 degrees C. The humidity was regulated roughly by keeping a flat pan of saturated sodium chloride in the bottom of the incubator (12 by 14 by 17 inches). The flour was changed at intervals of approximately 1 month.

The beetle eggs were sifted out with a no. 4 silk bolting cloth sieve at 3-day intervals over the entire observation period, and no attempt was made to determine the percentage of the eggs that were viable.

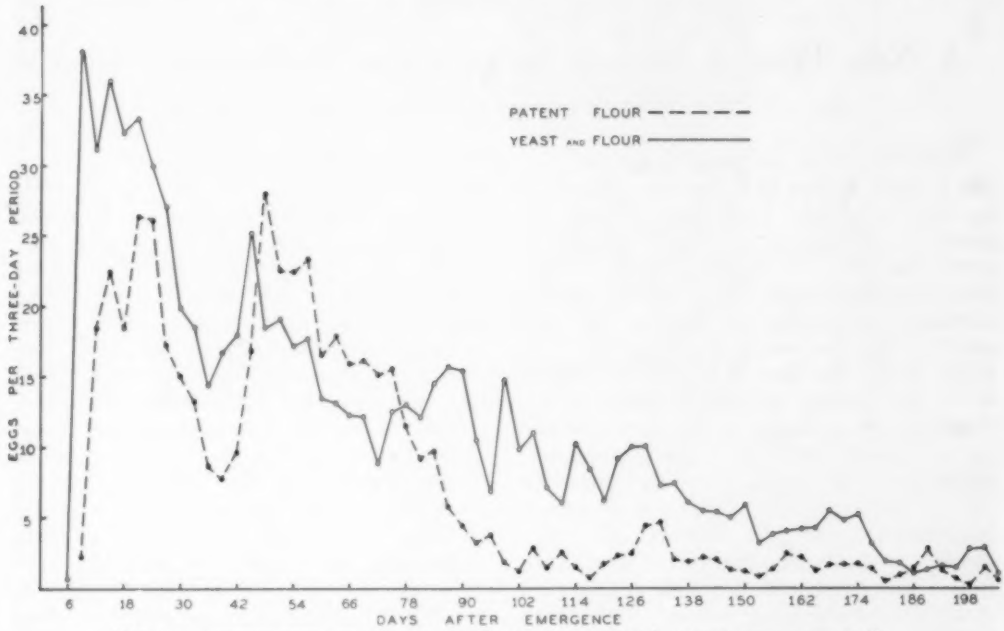

FIG. 1.—Average eggs per 3-day period (39 pairs yeast fed, 19 pairs not yeast fed).

RESULTS.—That the inclusion of yeast in the diet raised the production of eggs is shown by the fact that the yeast-fed beetles totaled 742.1 ± 47.4 (S.E.) eggs per female, while those not fed on yeast totaled only 490.0 ± 37.7 eggs per female. The figures for egg production on yeast-supplemented flour are roughly comparable to the records of Good (1936) on whole-wheat flour. One yeast-fed beetle produced 1,547 eggs—the highest recorded figure for a *Tribolium* individual—and 8 others produced over a thousand each. These might have produced a few more had not a failure of the incubator thermostat abruptly terminated the experiments at the beginning of the eighth month. At this time, 26 yeast-fed females and 6 females not fed on yeast were killed. The lowest record for a yeast-fed beetle was 255 eggs. The highest record for a beetle on plain flour was 828 eggs and the lowest 148 eggs.

In fig. 1, the average production of eggs by 19 pairs on plain patent flour and 39 pairs on yeast-supplemented patent flour is indicated for each 3-day period from emergence to death. It will be noticed that the beetles on the yeast-supplemented diet produced distinctly more eggs during the first 7 weeks, fell behind the next 4 weeks and then assumed the lead again for the remaining 4 months or more of life. This would indicate that the yeast diet stimulated the early deposition of eggs, an indication supported by the arrangement of the production peaks, those of the yeast-fed individuals preceding those of the non-yeast-fed individuals. The presence of the two distinct production peaks on each type of feeding would suggest that the eggs tend to be matured in batches or waves.

The highest individual egg production

on the yeast medium for any one 3-day period was 82, an average of 27.3 eggs for each of the 3 days, and in 19 of the 3-day periods, the beetles averaged 18 eggs or better per day. The highest record on plain patent flour was 22 eggs for each of the 3 days in the period and for only two periods did the *Tribolium* beetles average better than 18 eggs per day.—12-7-38.

LITERATURE CITED

Bushnell, R. J. 1938. The relation of nutritional levels to the growth of populations of *Tribolium confusum* Duv. I. Growth of larval, pupal and adult populations in cornmeal and in cornmeal supplemented with yeast. Ann. Ent. Soc. Amer. 31(3): 345–51.

Good, N. E. 1936. The flour beetles of the genus *Tribolium*. U. S. Dept. Ag. Tech. Bul. 498. 57 pp., 22 figs.

A New Pest of Books, *Neogastrallus librinocens* Fisher

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Most books in the Gulf Coast area of the United States that become damaged by the so-called "book borers" are injured by the cigarette beetle, *Lasioderma serricorne* (F.), or the drug store weevil *Stegobium paniceum* (L.). Books badly damaged by another anobiid beetle were received by the writer on November 15, 1937, from the Rev. Charles McGinley of St. Leo Abbey, St. Leo, Fla., with the statement that many of the books in the Abbey library had been ruined. Specimens taken from the books were forwarded to W. S. Fisher of the Division of Insect Identification of the Bureau of Entomology and Plant Quarantine and were found to represent a new genus and species, described and named *Neogastrallus librinocens* Fisher (Fisher 1938).

DESCRIPTION AND BIOLOGY.—The uniformly dark reddish-brown, moderately shiny beetles, sparsely clothed with short, recumbent grayish pubescence, vary in size but average about 2.4 millimeters long and 1.2 millimeters wide. They appear less robust than adults of either the cigarette or the drug store beetles. The larvae, white in color except for the lower one-third of the head, are from 2 to 3 millimeters long when well grown and are more slender than the larvae of *Lasioderma serricorne* or *Stegobium paniceum*, as indicated in fig. 1. The larvae make burrows slightly more than 1 millimeter in diameter, fig. 1. Nothing is known concerning the biology of the insect except that in November, 1937, and in April and June, 1938, all stages were present in books examined.

INFESTATION IN FLORIDA FOUND ONLY AT ST. LEO AND ST. AUGUSTINE.—A visit to St. Leo during April, 1938, revealed that the most seriously injured books had been presented to the Abbey from the estate of Bishop Moore of St. Augustine, Fla., who died July 20, 1901. This fact supplemented with the statement by the Rt. Rev. Abbot Francis Sadlier, head of the institution at St. Leo, that books in the rectory of the cathedral at St. Augustine were infested, led the writer to visit St. Augustine. With the cooperation of the Rev. I. Nunan and the Rev. John H. O'Keeffe, the books of the rectory were examined. They were in some instances badly infested. Later, in June, the library of St. Joseph's Academy, St. Augustine, was found very generally infested. It was also learned that the early cathedral records had been so damaged by anobiids that they were reconditioned during 1937 by the National Archives to prevent their utter destruction. Through the courtesy of Mrs. Katherine S. Lawson of the St. Augustine Historical Society and of the librarians of the St. Augustine, Key West, Tampa and Miami public libraries, examinations in these libraries were made but they failed to show the presence of *Neogastrallus*.

With everything pointing to the collections of the late Bishop Moore and the Cathedral records as the original source of the infestations at St. Leo and St.

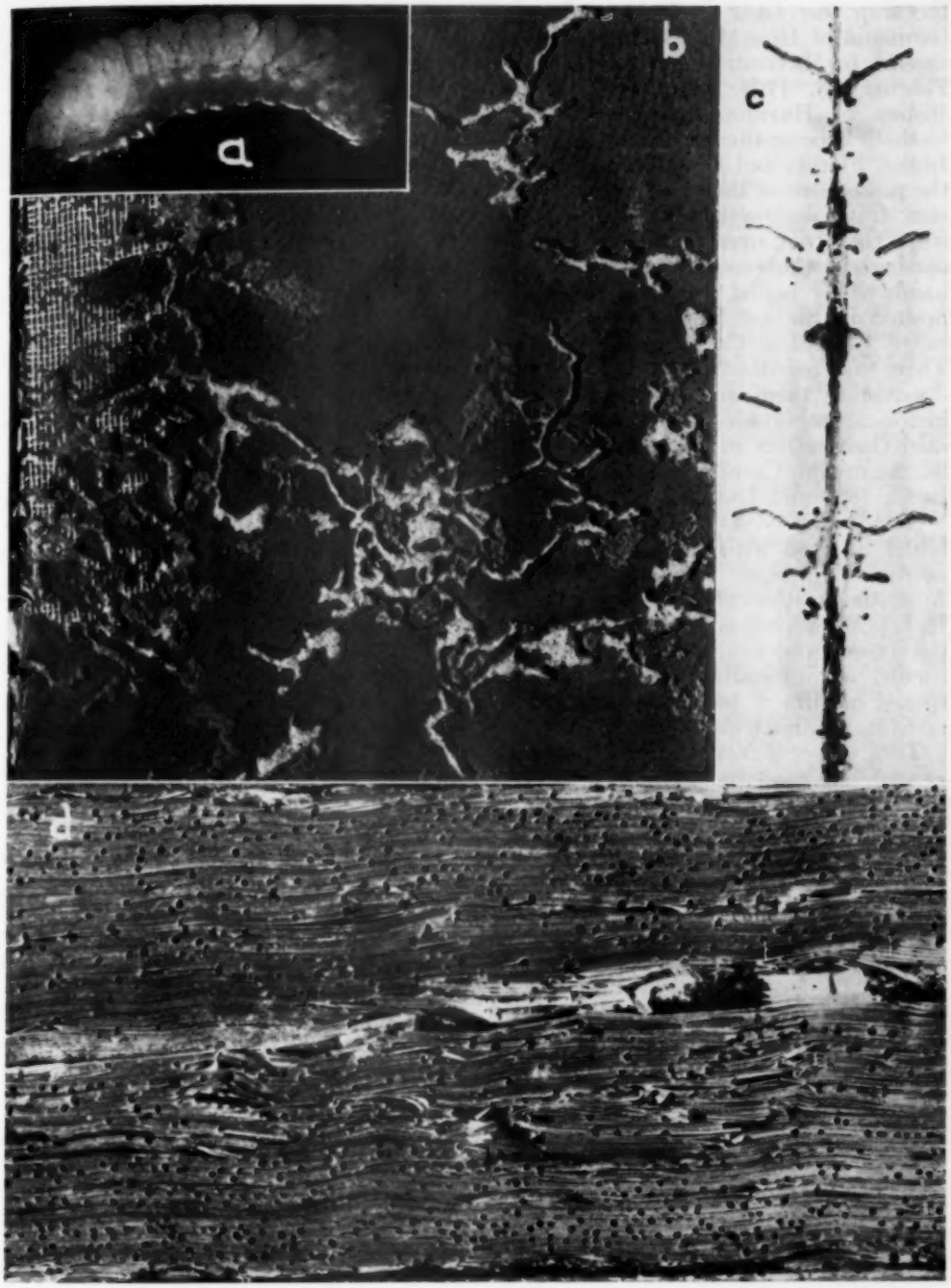

FIG. 1.—*Neogastrallus librinocens* Fisher: *a*, mature larva (×18); *b*, larval burrows in sheepskin binding, and also results of attack upon fabric binding; *c*, results of typical attack at sewed edges of pages when infestation is starting; *d*, adult emergence holes in edges of pages in advanced infestation, and also broken edges of pages where fingers have been inserted to force book open. All natural size except *a*.

Augustine, it was learned from Father Nunan that Bishop Moore's aptitude for historical research had led him to discover that all the records of the Cathedral, including the vital statistics and church furnishings, had been loaded into

the ship *Our Lady of Light*, under the command of Don Marcos Capitillo, and carried to Havana, where they arrived February 6, 1764. This effort of the Bishop of Havana, in charge of the Catholic diocese then including the West Indies, Florida and Louisiana, to protect the possessions of the St. Augustine Mission from destruction by the English when they took over the rule of Florida, resulted in the records, in the form of handwritten bound volumes, being deposited in the archives of what is now called Columbus Cathedral in Havana. There they remained until Bishop Moore, discovering them and recognizing their historical importance to Florida, negotiated their return to the archives of the St. Augustine Cathedral, some time between 1890 and 1900.

As no other books in Florida had been found infested with *Neogastrallus librinocens* except those originating in the St. Augustine Cathedral or in the house of Bishop Moore, it was suspected that when the records were returned from Cuba they carried an infestation which later was spread in gifts of books to the Catholic institutions above mentioned.

To discover if *Neogastrallus librinocens* existed in Cuba, the writer visited Havana in June, 1938, and had no difficulty in finding *Neogastrallus* infesting books in all book stalls visited, in the National Library in the Capitol Building and in the Columbus Cathedral. In the closely guarded archives of the Columbus Cathedral itself some of the unused volumes of old records, some dating back to the sixteenth century, were so badly riddled by *N. librinocens* and *Catorama bibliothecarum* Poey (det. W. S. Fisher) that the pages could not be turned, because of fluid emitted by the larvae in building burrows and pupal chambers.

MODERN AND ANCIENT BOOKS INFESTED.—Both modern and old books are attacked. Injury is greatest, usually, to the bindings, perhaps due to the presence of glue used in applying the coverings. Cloth, threads and string used in holding pages together are cut by the feeding larvae, with the result that the binding breaks and the leaves fall out. Some badly infested books cannot be opened except by main force, because of the secretions of the larvae made in constructing their pupal chambers.

NEW PARASITE SOMETIMES VERY ABUNDANT.—Parasites collected from infested books in St. Augustine have been identified by C. F. W. Muesebeck as a new species, *Heterospilus anobiidivorus* (Muesebeck 1939). Numerous cocoons of the parasite were found in the burrows of *Neogastrallus* in both Florida and Havana. In one book, 21, 26, 19, 33 and 20 cocoons were counted in the burrows on pages 1, 39, 86, 166 and 244, respectively. In a second book, 10, 22, 26, 40, 27, 10 and 25 cocoons were found in the burrows in pages 200, 214, 288, 316, 400, 454 and 506, respectively. It seems probable that this parasite, much more abundant in Havana, but present in St. Augustine, is an important control agent.

FUMIGATION EFFECTIVE.—The libraries of the St. Leo Abbey and St. Joseph's Academy, and books taken to the latter from the rectory of the St. Augustine Cathedral, were fumigated in June, 1938, with hydrocyanic acid gas, an equivalent of 1 pound of sodium cyanide being used in each 1,000 cubic feet of space. Examination of books at St. Leo two weeks after fumigation showed no living insects. No living insects could be found in the fumigated books at St. Leo and St. Augustine about one year after fumigation.

SUMMARY.—A new anobiid pest of books, *Neogastrallus librinocens* Fisher, was recorded during 1938 from St. Leo and St. Augustine, Fla. It probably was introduced with old records to the rectory of the St. Augustine Cathedral with the return, about 1890–1900, of the records from Havana, where they were taken from St. Augustine by the Spanish in 1764. Although widespread in Havana, infestations were not found during 1938 in the public libraries of Key West, Tampa, Miami or St. Augustine. Both old and modern books are affected. Bindings containing glue seem most severely affected, but some books with paper covers are ruined. The feeding burrows of the larvae cut the binding materials, causing the pages to fall out. The pages themselves may be riddled and cut by burrowing larvae, and firmly stuck together by the cementlike material emitted by the larvae in constructing their pupal chambers. A parasite, *Heterospilus anobiidivorus* Mues., was found in St. Augustine and Havana and evidently is an important factor in control.—1-9-39.

LITERATURE CITED

Fisher, W. S. 1938. A new anobiid beetle (Coleop.; Anobiidae) injurious to books. Proc. Ent. Soc. Wash. 40: 43–44.

Muesebeck, C. F. W. 1939. A new species of *Heterospilus* parasitic in an injurious anobiid. Proc. Ent. Soc. Wash. 41: 62–63.

Tests of Soil Treatments for the Control of the Fire Ant, *Solenopsis geminata* (F.)

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Practically every publication dealing with control measures for ants suggests the use of some soil fumigant, but there are only two references in the literature on the relative effectiveness of different soil treatments for species of *Solenopsis*. Clark (1931) in experiments with *S. geminata* reported calcium cyanide dust to be more effective than carbon disulfide, miscible carbon disulfide, paradichlorobenzene, sodium fluoride, tobacco dust or sulfur-naphthalene. Mallis (1938) reported that repeated applications of a mixture of 1 part of carbon disulfide to 3 parts of carbon tetrachloride usually gave very satisfactory control for *S. xyloni* var. *maniosa* Wheeler. He also used lime, slaked and unslaked, dusted under houses, to drive out fire ant colonies. Mallis stated that he had used carbon disulfide emulsion and corrosive sublimate treatments, but that additional work was needed to prove their efficiency.

The experiments discussed in this paper were conducted in southern Georgia on Ichuaway Plantation, near Newton, Baker County, and in northern Florida on Forshala and Horseshoe Plantations, near Tallahassee, Leon County. In the Georgia area the soil is coarse and sandy for at least 6 feet in depth (no soil survey has been made). The Florida area is an Orangeburg fine sandy loam with the top 4 to 15 inches a fine sandy loam and the subsoil for at least 36 inches a red sandy clay. Underlying beds of sand are sometimes present at 5 to 10 feet.

METHODS OF CHECKING RESULTS.—If no activity of a treated colony was noted at the time of the observation, the ant mound was dug out and thoroughly examined for live ants. If none could be found in or around the mound, the colony was recorded as inactive. Observations were continued at frequent intervals for 3 months following treatment.

The results as indicated by the percentages of inactive colonies are somewhat misleading, since the numerical reduction of ants is not shown. Evaluation of the insecticides tested in these experiments is based on actual data presented and also on the author's observations of the reduction in size of the colonies. The final comparison of the tests is based on two observations, one made 1 week and the other 3 months after treatment. The increase in the percentages of inactive colonies between the two observations is the result of the disappearance of very small and scattered activities following the application of the insecticide. Since the fate of these small groups of ants frequently cannot be determined, the comparison of the results as recorded 1 week after treatment is more reliable.

The method used by the Forshala Plantation (1931–36) in applying the cyanide was to punch, with a sharp-pointed stick, two to six holes about 6 to 8 inches deep in each colony mound and then to pour 1 to 2 quarts of a cyanide solution (1 ounce of sodium cyanide to 1 gallon of water) into these holes. Observations by the author on 553 colonies treated in this manner by the plantation crew in 1936 showed 29 per cent of the colonies to be inactive the first week after the treatment and 66 per cent at the end of 3 months. Part of these colonies were treated when the soil was dry to a depth of 8 to 12 inches in the mounds and part following a heavy rain. Of the 221 colonies treated during the dry weather, 31 per cent were inactive at the end of the first week and 49 at the end of 3 months; of the 332 fumigated following the rain, 28

* Acknowledgments are due the managers of Ichuaway, Forshala and Horseshoe Plantations for their cooperation. The author is especially grateful to H. L. Stoddard and E. V. Komarek of the Cooperative Quail Study Association, for their cooperation and counsel during these studies.

per cent were inactive at the end of the first week and 77 per cent at the end of 3 months. One hundred colonies treated with dry sodium cyanide eggs (1 ounce of cyanide placed 2 to 12 inches deep in each colony) by the Forshala Plantation crew during May and June, 1937, were observed by the writer. At the end of the first week 64 per cent of the colonies were inactive and, at the end of 3 months, 53 per cent.

The complete history of these small activities is obscured by the following three main factors: (1) The habit of small groups of ants of showing no signs of activity outside the nest over periods as long as several months; (2) rank growth of herbaceous vegetation, consisting mostly of broomsedge, *Andropogon virginicus* L., and partridge-pea, *Chamaecrista fasciculata* (Michx.) Greene, interposing a considerable handicap to accurate observations; and (3) the impossibility of determining in all cases whether a colony has been destroyed or whether it has migrated through underground passages.

Unless otherwise stated, the data presented are for colonies treated in the spring and early in the summer.

SODIUM CYANIDE.—Preliminary reports (Travis 1938a, 1938b) pointed out that sodium cyanide has been used for 7 years by Forshala Plantation as a means of reducing fire ants to protect young quail at the time of hatching. Not only have ant colonies been treated over the entire plantation (1932–37), but special efforts were made to treat those within a 50-foot radius of all quail nests under observation (1931–37). It is obvious, from a study of this and adjacent property, that the colonies have been reduced materially in size by the cyanide treatments, but there is still a dangerously high population of ants on Forshala Plantation.

As a test of the method used by the plantation, an attempt was made to destroy with sodium cyanide all colonies in two "eradication" fields.† It was hoped that fire ants could be removed from these areas and that the rate of reinfestation could be observed.

One area of 5 acres on Forshala Plantation received five treatments in 1935, eight in 1936 and one in 1937. There were no records of the number of colonies in 1935, but 88 were recorded in 1936, 171 in 1937 and 89 in 1938. The second area, a 3-acre tract on Ichuaway Plantation, was treated 4 times in 1936 and 12 times in 1937. In 1936 there were 61 colonies on this area, 139 in 1937 and 144 in 1938. The numbers of colonies given above are those present at the beginning of each season.

The liquid method for the application of sodium cyanide was tested by pouring solutions of various strengths both into holes punched in the mounds and on top of the mounds so that they broke through the top crust and ran down the galleries. The cyanide solution was found to be more effective when poured down the galleries than when poured into holes punched in the mound, table 1; effectiveness was judged by considering the reduction in size of colonies and the number of colonies completely destroyed.

To check the results of a technique used by Forshala Plantation in 1935, in one test at Ichuaway Plantation, table 1, the holes were covered with soil following the application of the fumigant. The extra labor cost does not justify the slight advantages noted for this procedure in either the sandy or the clay soils. In all tests with cyanide solution 1 gallon of the liquid was applied to each colony.

Dry sodium cyanide eggs (1 ounce) were also applied to colonies to determine the efficacy of these as a control measure. The cyanide was placed at the desired depth in holes punched in the center of the anthill either with a sharpened stick or with a steel rod. The hole was then filled with loose soil. Although the data, table 1, indicate that this method is not so efficient as the use of cyanide in solution, the numerical reduction of ants is sufficiently high and the cost of application so much less that the dry cyanide treatments are more practical than the wet and should be considered in control campaigns. The dry-egg method was less effective in sandy than in clay soils.

In one experiment (1937) dry sodium cyanide eggs (1 ounce per colony) were placed 12 inches deep in 13 colonies, and then one cup of acid solution (1 ounce of sulfuric acid to 1 ounce of water) was poured into the hole. The hole was immediately plugged with soil. This time consuming and dangerous method of

† All treatments were applied by the writer except those of 1935, which were made by H. S. Peters, formerly of the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture.

treatment offered no advantage, table 1, over either the liquid or the dry applications.

The most promising results with soil treatments were obtained in the spring from March to the middle of May, and and September are not included in the tabulated data.

CALCIUM CYANIDE.—In 1936 calcium cyanide dust was tested in both soil types. The dust was poured down holes punched in the center of the colony

Table 1.—Percentages of colonies showing no activity after treatment with sodium cyanide applied either in aqueous solution or dry into holes punched in the colony mound, Tallahassee, Fla., and Newton, Ga., 1936, 1937 and 1938.

QUANTITY PER COLONY, OUNCES	PLACE OF APPLICATION	NUMBER OF COLONIES TREATED	PERCENTAGE OF COLONIES SHOWING NO ACTIVITY AFTER TREATMENT	
			1 Week	3 Months
		Tallahassee, Fla. (Clay Soil)		
In solution				
1	In galleries	137	53.6	86.1
2	In galleries	6	33.3	83.3
1	In holes	765	30.8	63.8
Dry	In soil at indicated depth, inches			
1	3	80	42.5	42.5
1	6	80	45.0	48.9
1	12	185	52.4	42.7
1	24	85	28.1	38.8
1	4–12	15	86.7	60.0
1	12*	13	38.5	30.8
½	3	5	40.0	40.0
½	6	5	0.0	0.0
½	12	5	0.0	20.0
½	24	5	20.0	0.0
¼	3	5	40.0	60.0
¼	6	5	0.0	40.0
¼	12	5	0.0	0.0
¼	24	5	20.0	20.0
		Newton, Ga. (Sandy Soil)		
In solution				
1	In galleries	52	48.1	
2	In galleries	44	56.1	
1	In holes	169	48.5	
2	In holes	115	55.7	
3	In holes	64	45.3	
3	In holes†	26	57.7	
Dry	In soil at indicated depth, inches			
1	3	25	36.0	
1	6	66	28.0	
1	12	31	19.4	
1	24	23	4.3	
1	12–18	5	40.0	
2	12–18	41	48.8	

* Plus acid solution.
† Holes covered.

the least promising late in the summer and early in the fall. One ounce of sodium cyanide solution applied to each of 15 colonies in August and September failed to destroy a single colony, and 2 ounces per colony destroyed only 15 per cent of 13 colonies. The experiments for August

mounds, after which the holes were filled with soil. In one case (Forshala Plantation) the mound was scraped away, 2 tablespoonfuls of the dust were sprinkled over the exposed galleries, and the soil replaced; this colony was destroyed by the treatment.

At Ichuaway Plantation, 11 colonies were each treated with 1 heaping tablespoonful of calcium cyanide placed at depths of 18 to 24 inches, and 21 were treated likewise with 2 heaping tablespoonfuls of the dust. One week later 73 per cent of the first group of colonies and 57 per cent of the second were inactive.

Thirteen colonies (Forshala Plantation) received 1 heaping tablespoonful of calcium cyanide each in holes 12 to 18 inches deep. One week after this treatment 17 per cent were inactive and 3 months later 92 per cent. One colony treated with 1 level tablespoonful of the dust placed 12 inches deep in the mound survived the treatment. The calcium cyanide gave slightly better results than the sodium cyanide, in either dry or liquid form, but the additional cost of the chemical (calcium cyanide 2.3 cents and sodium cyanide 1.4 cents per colony) and the danger of handling powdered material does not justify its use over large areas.

CHLOROPICRIN.—Chloropicrin was applied in holes punched to various depths in the anthills and then the holes were plugged with soil.

In November, 1936, two colonies were treated with 5 cubic centimeters, one with 10 cubic centimeters, and one with 15 cubic centimeters of this material placed 8 inches deep in the mound. Although many ants were killed, all the colonies remained active.

In the spring of 1937, 28 colonies were treated with this fumigant placed 6 to 8 inches deep, and 5 with the fumigant placed 30 to 36 inches deep. Of those with the chemical placed 6 to 8 inches deep, six colonies received 5 cubic centimeters, seven 10 cubic centimeters, seven 15 cubic centimeters, six 25 cubic centimeters, one 50 cubic centimeters and one 100 cubic centimeters. At the end of the first week the respective percentages of inactive colonies for these treatments were 17, 29, 43, 33, 0 and 100, and at the end of 3 months the percentages were 50, 57, 71, 33, 0 and 100. Of the colonies with the fumigant applied 30 to 36 inches deep, one received 5 cubic centimeters, two 10 cubic centimeters, one 50 cubic centimeters and one 100 cubic centimeters. At the end of the first week only two colonies were inactive, one having been treated with 5 cubic centimeters of the chemical and the other with 10 cubic centimeters, but at the end of the 3-month period only the one receiving the 5-cubic-centimeter treatment remained active.

CARBON DISULFIDE.—Carbon disulfide was tested undiluted, in emulsion (1 part of sulfonated castor oil to 3 parts of carbon disulfide) and in emulsion combined with sodium cyanide. When used undiluted, it was poured into a hole punched in the colony mound and the hole was then filled with soil. The emulsion forms were mixed with water and poured directly down the galleries into the mound. The results obtained with this chemical, table 2, at least with the single-application method of treatment, appear no more promising than those with sodium cyanide, and the expense is much greater.

CARBON TETRACHLORIDE.—This chemical has been tested undiluted and in emulsion form (1 part of sulfonated castor oil to 3 parts of carbon tetrachloride). The method of application was the same as that used for carbon disulfide. The results obtained, table 2, with this gas appeared to be only slightly better than those with the carbon disulfide.

SULFUR DIOXIDE.—This gas was applied through a piece of copper tubing inserted in a hole punched 3 feet deep in the center of the colony mound. Soil was tamped around the tubing to prevent undue escape of the gas and the hole was plugged with soil after the tubing had been removed.

In September, 1937, sulfur dioxide was applied to six fire ant colonies, one receiving 1 pound, two 2 pounds, two 8 pounds and one 10 pounds of the gas. Small activities persisted for about a week, but after this time no living ants were seen. In March, 1938, five colonies each were treated with 1, 2, 5 and 10 pounds per colony. One week after the fumigation all those receiving 1 and 2 pounds, 20 per cent of those given 5 pounds and 60 per cent of those given 10 pounds were inactive. Three months later 20, 100, 40 and 100 per cent, respectively, were inactive.

It should be noted that the use of sulfur dioxide was very destructive to vegetation. In several instances plants at a distance of over 70 feet from the point of application were killed. One year later there were still no plants growing within a diameter of about 3 feet around the area where the gas was applied.

SULFUR.—Finely divided sulfur was tested on five ant colonies at the rate of 1 pound per colony. Part of the powder was poured down a hole punched 3 feet deep in the center of the colony and part was mixed with the top soil of the mound. No ants seemed affected, and all moved to new locations.

DERRIS.—Commercial derris powder (rotenone content not determined) was applied in sufficient quantities to cover the colony mound with a thick coating of dust. At the time of the application of this insecticide the colony was stirred with a stick to expose as many ants as possible to the powder. Three hours after treatment many partially paralyzed ants were seen, and large numbers of dead ants were carried from these colonies during the following week. One week after treatment 20 per cent of the colonies showed no activity, but 3 months later all of the colonies were active and all of them appeared to be normal.

SODIUM FLUORIDE.—Five colonies were treated with sodium fluoride (commercial, 90–95 per cent) with the same technique as used in the derris tests. Many dead ants were carried from the mounds during the 2 weeks following treatment. In two of the five colonies a wingless queen was found in the pile of dead ants but it was not known whether these were mother queens or alate queens from which the workers had removed the wings before they were carried to the dump heaps. One of these colonies eventually disappeared whereas the other survived the treatment. It was interesting to note that the ants refused to excavate in the dusted mounds, and the survivors moved to new locations. At the end of 1 week 40 per cent of the colonies were inactive and at the end of 3 months 60 per cent.

Table 2.—Percentages of colonies showing no activity after treatment with various insecticides, Tallahassee, Fla., 1937 and 1938.

INSECTICIDE	TREATMENT PER COLONY, CUBIC CENTIMETERS	NUMBER OF COLONIES TREATED	PERCENTAGE OF COLONIES SHOWING NO ACTIVITY AFTER TREATMENT	
			1 Week	3 Months
Carbon disulfide	2– 25	41	14.6	34.3
	30– 60	11	10.0	81.8
	80–192	16	31.3	62.5
	220–320	2	0.0	100.0
Carbon disulfide emulsion	2– 25*	22	9.1	27.2
	30– 60	22	33.3	59.1
	80–192	18	50.0	83.3
	220–400	4	0.0	100.0
Carbon disulfide emulsion plus 1 ounce of sodium cyanide†	6– 18	10	0.0	10.0
	30– 60	10	30.0	50.0
	90	5	40.0	40.0
Carbon tetrachloride	6– 12	10	50.0	60.0
	48	10	40.0	40.0
	96	5	80.0	80.0
Carbon tetrachloride emulsion	6– 12*	10	20.0	0.0
	48	10	60.0	0.0
	96	5	40.0	20.0

* Emulsion volumes are given as carbon disulfide and carbon tetrachloride equivalents.
† September treatment.

DISCUSSION.—It was interesting to note that up to a week following the application of the gases of high density there was a moderate number of live ants present in most of the mounds. Many of them disappeared rapidly within the next 2 weeks and many of the colonies became inactive. Just what happened to these ants is unknown, since no sign of migration or new colony mounds could ever be found. The surviving colonies eventually migrated to new locations. In the case of the cyanide treatments, the surviving ants usually moved immediately. The

erratic results obtained are due probably to the small samples.

Owing to the heavy carpet of herbaceous vegetation, colonies can be located easily only following the controlled burning of the plantations. Ant control programs are thus necessarily limited to the period from the middle of March to the middle of June.

Since many of the activities following treatment cannot be accurately followed, the percentage of active colonies 1 week after treatment is the most reliable for determining the value of treatments.

SUMMARY.—Repeated applications of sodium cyanide not only failed to eliminate fire ants from experimental areas, but the number of colonies was apparently increased by the treatments. There was, however, a large numerical reduction of ants. Single applications of sodium cyanide in solution were most effective in clay soils when poured down the galleries instead of into holes punched in the mounds. Dry cyanide treatments did not destroy so many colonies as the liquid, but the results indicate that this is a method to be considered in control campaigns. Calcium cyanide dust gave slightly better results than the sodium cyanide, but the additional cost of the chemical and the danger of handling powdered material do not justify its use over large areas. Gases of high density, such as chloropicrin, carbon disulfide, carbon tetrachloride and sulfur dioxide, were not effective unless the applications were so large that the expense was prohibitive. Such powders as sulfur, derris and sodium fluoride were ineffective. The most promising results with soil treatments were obtained in the spring. The evidence, however, indicates that soil treatments can effect only a temporary reduction and not an elimination of fire ant colonies.—2-3-39.

LITERATURE CITED

Clark, S. W. 1931. The control of fire ants in the lower Rio Grande Valley. Tex. Ag. Exp. Sta. Bul. 435. 12 pp., 4 figs.

Mallis, Arnold. 1938. The California fire ant and its control. Pan-Pacific Ent. 14: 87–91.

Travis, Bernard V. 1938a. The fire ant (*Solenopsis* spp.) as a pest of quail. JOUR. ECON. ENT. 31(6): 649–52.

Travis, Bernard V. 1938b. Fire ant problem in the Southeast with special reference to quail. Third N. Am. Wildlife Conf. Trans., pp. 705–708.

Time and Temperature in Relation to the Destruction of Sugar-Tolerant Yeasts in Honey

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Many thousands of dollars are lost annually through fermentation of honey. Increased production has made it necessary to have honey on the market the year round. It is under commonly available conditions of storage that fermentation takes place. The recently developed method of processing has decreased the loss in storage of granulated honey to some extent, but more information regarding thermal death points of yeasts is required for improving this process and preventing loss in unprocessed stocks.

Honey in the liquid state is rarely found fermented. Fermentation takes place when the dextrose crystallizes out as a monohydrate and leaves the levulose in solution with a considerably increased water content.

Much work has been done both in the United States of America and in Canada to determine the cause of fermentation and discover a means of control. There are three known methods of control. Marvin (1928) suggests storing honey below 52 degrees F. The limiting factors in this practice are the expense involved and the fact that the honey would be subject to fermentation upon removal from storage.

Lochhead & Farrell (1930b) suggest the use of chemicals as preservatives. This practice would be permissible under the pure food laws, but it has been opposed by the beekeepers.

* The writer is indebted to Dr. E. J. Dyce and W. G. LeMaistre for guidance and advice throughout the investigation and in the preparation of this paper. The author also wishes to thank Dr. A. G. Lochhead of Ottawa for the cultures of yeasts.

Heating has been found the most practical method in the control of fermentation for both the liquid and the crystallized trade. There are two methods of pasteurization now in practice.

1. The honey is heated to 145 degrees F. and held at this temperature for 30 minutes, or

2. It is heated to 160 degrees F. or more for a very short time.

These two methods are very efficient as far as the destruction of the yeasts is concerned, but some of the good qualities of the honey are often lost.

A lack of knowledge concerning the thermal death point of yeasts in honey has resulted in the use of high temperatures which impair the selling qualities of the honey. Overheating drives off the characteristic flavors; caramelizes the sugars, melts the resins and other inclusions, thus darkening the honey.

OBJECT.—The object of this investigation was to establish a minimum time and temperature curve by which honey may be pasteurized. The thermal death points of yeasts commonly causing fermentation have been reported in media other than pure honey, but there are conflicting reports on the thermal death points of these yeasts in honey.

REVIEW OF LITERATURE.—Work done by Fabian & Quinet (1928) shows that although organisms other than sugar-tolerant yeasts are present in honey, they are unable to grow because of the high osmotic index and the high hydrogen ion concentration. Dr. Lochhead (1929) showed that four types of *Zygosaccharomyces* and one of *Torula* were the only yeasts commonly found in fermented Canadian honeys.

Previous investigations have established the fact that probably all honeys are infected with sugar-tolerant yeasts, at least in some degree. Nussbaumer (1910) found evidence of yeasts in 34 out of 38 samples of Swiss honeys and 18 out of 23 foreign samples. Marvin (1928) expressed the belief that yeast cells are found in almost all honeys. Lochhead & Heron (1929) examined 191 samples of normal Canadian honeys and found sugar-tolerant yeasts in all samples.

A number of investigators have proved that fermentation is caused by the action of sugar-tolerant yeasts, capable of developing in concentrated sugar solutions. Non-osmophilic yeasts will not develop in honey.

Fabian & Quinet (1928) found that bacteria and molds predominate on a 10 per cent honey agar, but, if the honey is increased to 30 per cent, yeasts predominate and no bacteria are found.

In the work of various investigators the following conclusions regarding pasteurization of honey were reached.

1. Nussbaumer (1910) advised heating honey to 70 degrees C. (158 degrees F.) for 30 minutes.

2. Marvin (1928) found it possible to prevent fermentation of honey by holding it at 100 degrees F. for several months; by heating it to 122 degrees F. for 24 hours; or by heating it to 160 degrees F., pouring it into containers and sealing it while hot. He states, "Fermentation, provided the honey has been heated all the way through to this temperature, is immediately and completely stopped."

3. Thermal death point determinations according to Fabian & Quinet (1928) showed that the vegetative cells of *Zygosaccharomyces* were killed at a temperature of 50 degrees C. (122 degrees F.) for 10 minutes in broth and that the vegetative cells of *Torula* were killed at a temperature of 50 degrees C. (122 degrees F.) for 15 minutes in broth. In honey, the vegetative cells of *Zygosaccharomyces* were killed at a temperature of 60 degrees C. (130 degrees F.) for 5 minutes and *Torula* at 60 degrees C. (130 degrees F.) for 10 minutes.

The ascospores were killed at a temperature of 65 degrees C. (149 degrees F.) when held for 5 minutes in broth and 75 degrees C. (167 degrees F.) for 10 minutes in honey. Fabian & Quinet concluded that in order to pasteurize honey it should be heated to 145 degrees F. for 30 minutes.

PROCEDURE.—Inoculated honey for use in this investigation was prepared in the following manner. In order to obtain a large number of colonies, individual transfers of five yeasts, namely, *Zygosaccharomyces mellis*, *Z. nectarophilus*, *Z. richteri*, *Z. nussbaumeri* and *Torula mellis*, were made to 80 per cent honey broth. These broth cultures were incubated at 32 degrees C. (90 degrees F.) for 6 days and then stored in a refrigerator at about 30 degrees F. A 10-pound pail of liquid

honey, having a water content of 18.6 per cent, was inoculated by adding 15 cubic centimeters from each broth cul-

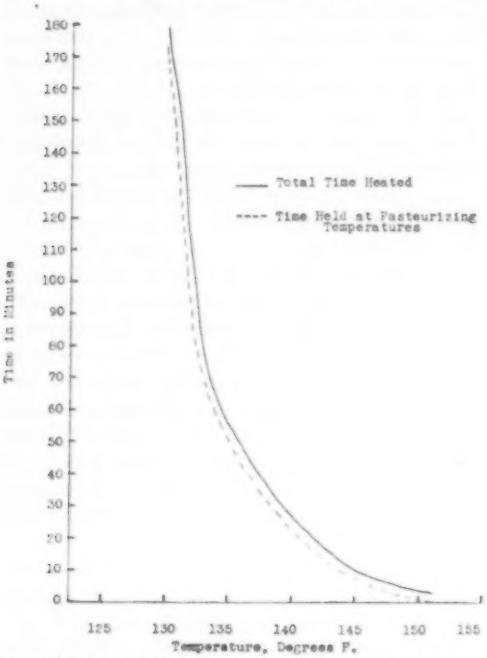

FIG. 1.—The dotted line shows, at any given temperature, the length of time necessary to heat and hold a honey of 18.6 per cent moisture in order to pasteurize it effectively. The solid line shows the total length of time that would be required to heat the same honey when in a layer 3.5 millimeters thick in order to pasteurize it effectively.

ture. This inoculated honey was stirred well and stored at room temperature.

The actual pasteurization tests were carried out in the following manner. Three cubic centimeters of the inoculated honey was introduced to the bottom of a sterile test tube 100 millimeters long and 12 millimeters wide (inside dimensions) by means of a sterile pipette. A sterile thermometer of 5 millimeter thickness was inserted into the test tube and left there throughout the pasteurizing. A water bath which could be maintained within ± 1 degree F. of any required temperature was used for the pasteurizing. In order that all samples might be started at a standard temperature they were brought to 100 degrees F. before being placed in the hot water bath.

As each sample was removed from the hot water bath it was cooled immediately to 60 degrees F. The time was recorded when the sample was put into the hot water bath and again when the sample reached 100 degrees F. during the cooling. The highest temperature reached and the duration of the heating was recorded. The sample was then corked and allowed to stand for 1 day at room temperature before being plated.

Fifty per cent sterile honey was used for the dilution blanks. Plates were made up of 1:100, 1:1,000 and 1:10,000 dilutions, media added and the plates incubated for 6 days at 32 degrees C. (90 degrees F.) before being counted. The media were poured at a temperature of 105–110 degrees F.

The formula used for the media was developed by Dr. Lochhead (1929) and is as follows:

1.	Honey	600.0 grams per liter
2.	Peptone	1.0 grams per liter
3.	K_2HPO_4	1.0 grams per liter
4.	$MgSO_4$	0.5 grams per liter
5.	Ammonium tartrate	0.5 grams per liter
6.	NaCl	0.1 grams per liter
7.	$CaCl_2$	0.1 grams per liter
8.	Agar	25.0 grams per liter

The honey broth contained 800 grams of honey per liter and other ingredients as for the agar media.

The agar was dissolved separately in 500 cubic centimeters of water by autoclaving. The warmed honey and other ingredients were added and the mixture brought to 1 liter with water. The pH was adjusted to 6.8 with concentrated sodium hydroxide.

All glassware, media and dilution honey were autoclaved at 15 pounds pressure for 20 minutes.

Table 1 shows the results of the experiments. The graph, fig. 1, is drawn from the results in table 1.

In order to determine the accuracy of the graph, inoculated honey was heated for varying times and temperatures on either side of the graph. The plates for this work were incubated at 32 degrees C. (90 degrees F.) for nine days before counting. The results as indicated in table 2 show the graph to be accurate.

It was noticed that there was a sudden drop in the number of colonies per cubic centimeter at a definite time for each temperature. Since Fabian & Quinet (1928) suggest that *Torula* is more resistant than *Zygosaccharomyces*, it was thought worth while to discover if this

Table 1.—Results of heating experiments with honey.

TEMPERATURE OF WATER BATH, DEGREES F.	TOTAL TIME HEATED, MINUTES AND SECONDS	COLONIES PER CUBIC CENTIMETER	HIGHEST TEMPERATURE REACHED, DEGREES F.	TIME HELD AT MAXIMUM TEMPERATURE, MINUTES AND SECONDS
130	150:00	1,000	130	146:00
130	165:00	600	130	161:00
130	180:00	0	130	176:00
135	50:00	1,000	135	46:00
135	54:10	100	135	50:40
135	58:15	0	135	54:40
135	60:00	0	135	56:00
140	12:35	120,000	140	8:40
140	20:35	400	140	16:40
140	23:15	600	140	19:40
140	25:35	0	140	21:40
145	3:45	1,500,000	142	Instant
145	10:35	800	145	6:40
145	11:40	0	145	7:40
145	12:43	0	145	8:40
150	3:40	15,000	146	Instant
150	4:10	1,000	150	Instant
150	5:45	0	150	1:40
155	2:45	7,000	147	Instant
155	3:50	6,000	149	Instant
155	3:40	500	150	Instant
155	3:35	0	151	Instant
155	4:34	0	153	Instant

drop was the result of the destruction of *Zygosaccharomyces* though not of *Torula*.

A sterile honey was inoculated with the four types of *Zygosaccharomyces*, and samples were heated to the temperature and for the time at which the sudden drop in colonies per cubic centimeter was noticed.

It was found that this sudden drop in count was not caused by the destruction of *Zygosaccharomyces* and the survival of *Torula*.

DISCUSSION.—To insure that the honey used in these experiments was properly inoculated, several counts were made on 1 cubic centimeter samples of both the broth cultures and the inoculated honey. It was found in all cases that yeast colonies were present in numbers too great to be counted in the one-millionth dilution.

There are some features of this investigation which may have some bearing on the practical application of the results obtained.

1. On microscopical analysis no ascospores could be found in the honey which was used. This analysis was carried out

Table 2.—Results of experiment to determine accuracy of the graph in fig. 1.

RUN NO.	SAMPLE NO.	TEMPERATURE, DEGREES F.	TOTAL TIME HEATED, MINUTES AND SECONDS	COLONIES PER CUBIC CENTIMETER	HIGHEST TEMPERATURE RECORDED, DEGREES F.	TIME HELD AT MAXIMUM TEMPERATURE, MINUTES AND SECONDS
10	22	137	35:45	1,200	137	31:40
	23	137	42:30	0	137	38:40
	25	142	17:20	400	142	13:40
	26	142	21:25	0	142	17:40
	27	147	5:30	500	147	1:40
	28	147	9:20	0	147	5:40
	Check	—	—	Numerous	—	—

by centrifuging the honey to obtain the maximum number of cells. All microscopic slides were stained. It cannot definitely be stated that no ascospores were present, but none were observed. Fabian & Quinet (1928) state that it takes much longer to destroy the ascospores than it does the vegetative cells. If there were no ascospores present in this honey, the times and temperatures as given in this thesis would apply only to honeys which did not contain ascospores.

2. The thickness of the layer of honey heated will have some effect on the time required to bring the honey from 100 degrees F. to the temperature of the hot water bath. A similar effect will also take place for the cooling. The layer of honey used in this investigation was 3.5 millimeters thick, and the average time required for it to be raised from 100 degrees F. to the temperature of the water bath was 3 minutes. The average time required to cool the honey down to 100 degrees F. was 1 minute.

3. The density or moisture content of the honey may have some influence on the pasteurization times and temperatures. The moisture content of the honey used in this work was 18.6 per cent.

4. While the particular honey used in this investigation did not appear to deteriorate under the conditions to which it was subject, this might not be true of all honeys.

5. It is hoped that these results may be of value as preliminary work for a commercial method of flash pasteurization, which will not injure the quality of the honey.

CONCLUSION.—The vegetative stages of the yeasts *Zygosaccharomyces mellis*, *Z. nussbaumeri*, *Z. richteri*, *Z. nectarophilus* and *Torula mellis*, which are those commonly causing fermentation in Canadian honeys, are destroyed when heated in a honey of 18.6 per cent moisture, to the temperatures and for the lengths of time as shown in the graph contained in this thesis.—1-6-39.

LITERATURE CITED

Dyce, Elton J. 1931. Fermentation and crystallization of honey. Cornell Univ. Ag. Exp. Sta., Ithaca, N. Y., Bul. 528. Oct.

Fabian, F. W., and R. I. Quinet. 1928. A study of the cause of honey fermentation. Michigan State Col. Ag. Exp. Sta. Tech. Bul. 92: 1–42.

Lochhead, A. G., and N. R. McMaster. 1931. Yeast infection of normal honey and its relation to fermentation. Sci. Agr. 11: 351–60.

Lochhead, A. Grant, and Doris A. Heron. 1929. Microbiological studies of honey. Canada Ag. Dept. Bul. 116 n.s.: 1–47.

Lochhead, A. G., and Leone Farrell. 1930a. Soil as a source of infection of honey by sugar-tolerant yeasts. Can. Jour. Res. 3: 51–64.

Lochhead, A. G., and Leone Farrel. 1930b. The effect of preservatives on fermentation by sugar-tolerant yeasts from honey. Can. Jour. Res. 3: 95–103.

Marvin, G. E. 1928. The occurrence and characteristics of certain yeasts found in fermented honey. JOUR. ECON. ENT. 21: 363–70.

Nussbaumer, Th. 1910. Beitrag zur Kenntnis der Honniggärung nebst Notizen über die chemische Zusammensetzung des Honigs. Ztschr. Untersuch. Nahr. u. Genussmtl. 20: 272–7.

Ventilating the Bee Colony to Facilitate the Honey Ripening Process*

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Ripeness or sugar concentration is of importance in standardizing honeys; it is a factor in granulation and also in spoilage by fermentation. Thin honey is often accompanied by delay in extraction or serious loss. The problem of sugar concentration turns attention directly to the honey ripening‡ process and the conditions which influence that process in the bee colony.

The normal ripening of honey would apparently be influenced by the following factors: the humidity, temperature and air movement within the hive, the amount

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‡ In this paper the term *ripening* refers only to the evaporation of water from the nectar, and ripeness of honey is expressed in terms of sugar concentration.

and sugar concentration of the nectar brought in each day, the area of empty comb space, the weather conditions outside the hive, and the rate of exchange of air between the inside of the hive and the surrounding atmosphere. This last phenomenon is known as *ventilation*. It is governed by the fanning of the bees themselves, and the number, size and position of openings to the colony. Of all the factors which influence honey ripening there are two over which the beekeeper can exert control, the area of comb space and the rate of ventilation. It was the author's purpose to determine when, where and to what degree the beekeeper can facilitate the honey ripening process by increasing ventilation.

The factors governing the honey ripening process have received little attention. Probably the most nearly complete consideration is that of Hambleton (1925) in an analysis of the factors involved in nocturnal loss of weight of a bee colony during the honey flow. This author correlated the net honey gain with the nocturnal loss immediately following the day's gain. The effect of diurnal gain on loss the second night was not significant. The author states, "This would indicate that the greater part of the necessary evaporation is accomplished the first night and little is left over until the second night." External factors, such as weather conditions, were not found to correlate significantly with nocturnal loss during the spring period. Hambleton calls attention to regional climatic and forage factors as causes of variations. He notes that the opinions of European workers range from 1 to 7 days in time required for the formation of honey.

O. W. Park (1928) demonstrated that sugar water evaporated more rapidly from honeycomb cells one-fourth full than from cells three-fourths full. This indicated that the quantity deposited in a comb is a factor in the rate of ripening. Jessup (1925) demonstrated that 500 to 800 cubic feet of air pass through the entrance of the colony every hour, and he suggested that since ventilation is more rapid during the day than at night the honey ripens more during the day. Greenleaf (1933) expressed the opinion that honey sometimes ferments for lack of ventilation.

The events of the honey ripening process have been determined by following the sugar concentration of the nectar from the time it was first collected in the field to the time when it became ripe honey in the combs. The work of O. W. Park showed that the ripening process may be divided into two parts; manipulating the nectar by the house bees to concentrate it before deposition in the combs, and evaporation after deposition. To study the latter step, Park (1933) developed a special technique which was followed in the present work. For uniform deposition of green honey in empty combs a special colony was prepared. Park's description follows:

"At 4:00 P.M. on July 18, a nucleus . . . was installed in a 10-frame Langstroth hive on two frames almost completely filled with brood, one frame of unsealed honey and seven frames of foundation. An abundance of young bees (house bees) were added by shaking bees in front of the nucleus. . . . Old bees flew home, but the young ones joined the nucleus. At eight o'clock the following morning a strong colony was removed from its stand and this small colony put in place of it. Thus the field force was added automatically in such a way that no ripe or partially ripe honey would be carried over into the experimental hive.

"Smoke was not used either in connection with the preparation of the special colony or later when removing combs or returning them. This precaution was taken in order or avoid causing the bees to fill their honeysacs with honey already stored, because the admixture of such honey would reduce the accuracy of the results."

Later in the day the comb of honey in the colony described was replaced by an empty comb which had been previously washed and dried. The bees were permitted to deposit nectar in the empty comb for part of the day. In the evening this comb was removed from the hive, the bees were brushed off and the sugar concentration of a sample of the nectar was determined with an Abbé refractometer. The comb was then caged to prevent the bees from removing the nectar or depositing more, and the caged comb was placed between combs of ripening honey in one of the supers of a normal colony. The ripening process was followed by removing the comb and determining the sugar concentration from

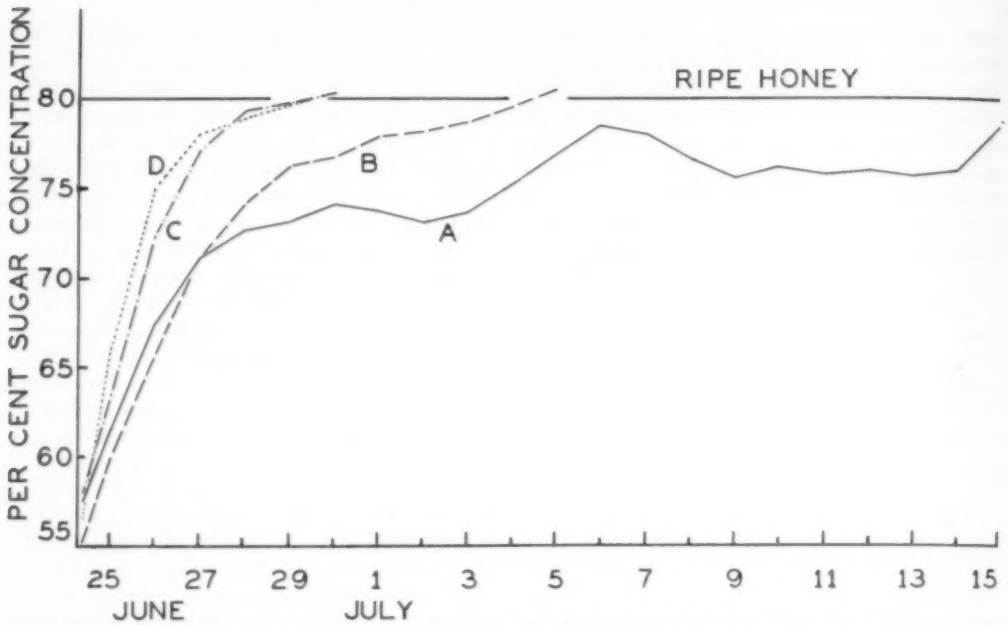

FIG. 1.—Rate of ripening for combs of series I, June 24 to July 15, 1933. Comb *A*, reduced ventilation; comb *B*, normal ventilation; comb *C*, normal ventilation plus one-half inch crack below top story; comb *D*, normal ventilation plus screen cover.

samples. The honey became ripe§ in three days.

In the present investigation the technique of Park was followed with certain modifications. The special colony was made as strong as possible, and four experimental combs (designated *A*, *B*, *C* and *D*) were used instead of one. Later in the day, after the combs were partially filled, they were removed from the hive and the bees brushed off. A sample of the green honey was pipetted from 30 cells distributed systematically over one side of the comb. Then a sample was taken from the other side in like manner. As soon as all four combs were sampled, sugar concentrations were determined with the refractometer. The average of the two sides constituted the datum for each comb.

In order to test the effect of ventilation on the ripening process, four colonies as nearly alike as possible were selected in which the experimental combs were to ripen. Then each colony was provided a different degree of ventilation. After the combs were caged, comb *A* was placed in a colony with the entrance reduced to a crack one-fourth inch deep across the width of the hive. The colony with comb *B* had normal ventilation as provided by the regular entrance three-fourths inch deep. The comb C colony in addition to the normal entrance had the top super slid forward one inch, providing so-called upward ventilation by a one-half-inch crack at the back. In the comb *D* colony, the usual inner cover was replaced by a wire screen, 16 wires to the inch. The telescoping outer cover was placed on four 1-inch blocks, so that an abnormal amount of ventilation was provided. Ripening of the green honey under these several degrees of ventilation was followed by sugar determinations at 24-hour intervals until the honey reached ripeness.

The experiment was repeated three times: the first set of combs, series I, was run from June 24 to July 15, 1933; series II from July 17 to 24; and series III from June 26 to 30, 1934. Daily observations are recorded in figs. 1, 2 and 3. In the last experiment, fig. 3, comb *D* had a poorer deposition of green honey than the other three and was eliminated.

In order to account as well as possible for any irregularities in results, factors other than ventilation were considered. The honey flow (or average daily honey gain) was determined from four colonies on scales. These colonies were weighed each evening. Average daily temperature and humidity data were calculated from hygrothermograph records. These data

§ Honey is considered ripe when it has a sugar concentration of at least 80 per cent.

Table 1.—Temperature, humidity and honey flow throughout the experiment.

DATE	AVERAGE DAILY TEMPERATURE, DEGREES F.	AVERAGE DAILY RELATIVE HUMIDITY, PER CENT	AVERAGE DAILY ABSOLUTE HUMIDITY, GRAINS PER CUBIC FOOT	AVERAGE DAILY HONEY FLOW, POUNDS PER COLONY
		Series I		
1933				
June 24	80.6	66.3	7.3	8.2
25	81.5	81.3	9.2	8.8
26	84.7	69.3	8.8	7.8
27	81.2	69.3	7.9	4.5
28	77.7	75.4	7.5	3.7
29	77.7	78.5	8.0	8.0
30	84.9	55.7	7.0	4.8
July 1	80.0	76.4	8.2	4.8
2	72.2	82.2	7.0	2.9
3	72.5	70.7	6.0	4.1
4	72.5	64.4	5.6	5.1
5	73.7	53.1	4.7	5.2
6	71.6	54.5	4.7	5.0
7	77.3	79.6	8.1	4.5
8	77.9	87.0	9.0	3.2
9	77.9	81.4	8.3	5.1
10	80.8	69.3	7.8	5.8
11	80.4	80.8	8.8	1.5
12	83.2	67.3	8.0	3.8
13	83.1	64.8	7.8	2.3
14	78.4	63.1	6.6	2.0
Average	78.6	71.0	7.4	4.8
		Series II		
1933				
July 17	71.9	62.2	5.3	2.9
18	77.2	61.5	6.1	1.9
19	79.6	67.0	7.0	2.2
20	81.6	64.6	7.4	1.9
21	77.0	79.6	7.9	0.4
22	77.7	76.6	7.6	0.5
23	70.8	86.4	7.0	0.1
Average	76.5	71.1	6.9	1.4
		Series III		
1934				
June 26	88.8	44.8	6.3	4.8
27	90.8	39.6	6.1	0.2
28	91.5	37.8	5.8	3.0
Average	90.4	40.7	6.1	2.7

for the experiment are presented in table 1.

VENTILATION AS AN IMPORTANT FACTOR.—Series I, fig. 1, shows marked differences in rates of ripening corresponding to different degrees of ventilation. Comb *A* with the least ventilation failed to ripen in 21 days, while comb *B* reached ripeness in 11 days, and combs *C* and *D* in 6 days. The rates of ripening increased as ventilation was increased. It appears that ventilation was the controlling factor in the honey ripening process. There is little difference between combs *C* and *D;* so we may conclude that ventilation has its limitations and carried to an extreme, as in the case of *D*, it was probably needless exposure of the colony.

It is important to observe the fluctuations of comb *A*. From July 2 to July 6 the absolute humidity was lower than the average for the series, table 1 and simultaneously comb *A* made a definite rise in sugar concentration. From July 7 to 13 the absolute humdity rose above the average, and the sugar concentration decreased to approximately 76 per cent, where it remained for the interval. On July 14 absolute humidity and honey flow both declined and the sugar rose to 78 per cent.

The weather conditions, table 1, throughout series I were very favorable for an abundant honey flow. The temperature was moderate and the humidity fairly high. The honey flow was 4.8 pounds per day per colony; however, during the week in which combs *C* and *D* ripened it was much higher than the average for the period. With more nectar brought in, conditions within the hive were less favorable for ripening. Had these conditions remained constant, combs *A* and *B* would have ripened even more slowly and the significance of increased ventilation would appear greater by comparison.

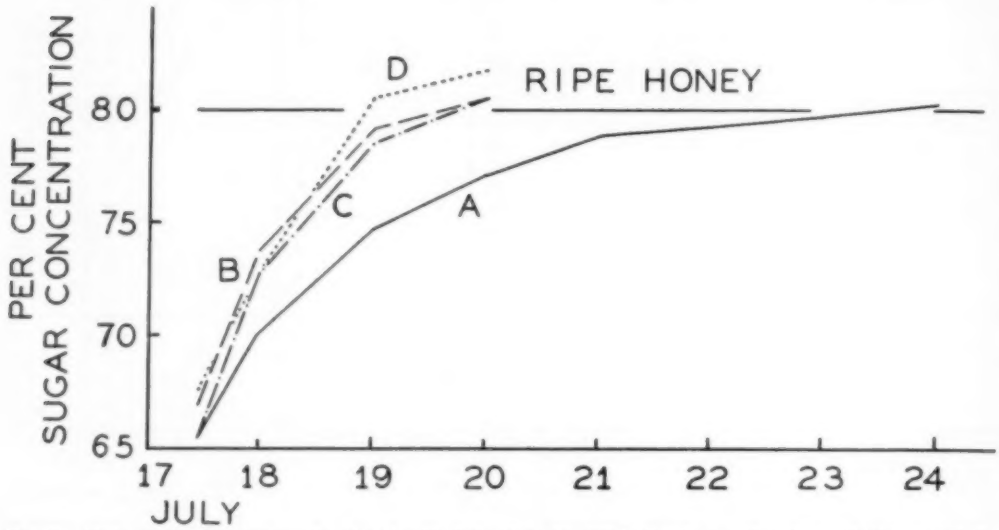

FIG. 2.—Rate of ripening for combs of series II, July 17 to 24, 1933. Comb *A*, reduced ventilation; comb *B*, normal ventilation; comb *C*, normal ventilation plus one-half inch crack below top story; comb *D*, normal ventilation plus screen cover.

The combs of series II, fig. 2, ripened much faster than those of series I. Comb *A* ripened in 7 days, combs *B* and *C* in 3 days and comb *D* in 2 days. These faster rates are attributed to the fact that the honey flow dropped from 4.8 pounds per day to 1.4 and ceased entirely at the conclusion of the series. With less nectar brought in, the humidity within the hive would be lower. Consequently, conditions were more favorable for the ripening process in the case of series II.

Comb *A* with reduced ventilation ripened much the most slowly. Combs *B*, *C* and *D* apparently ripened slightly faster as ventilation was increased. When initial concentrations are considered, these differences are of little significance. Under the conditions of series II an increase in ventilation above normal was apparently of little benefit in speeding up the rate of ripening. However, normal ventilation showed a significant advantage over reduced ventilation.

The combs of series III, fig. 3, ripened with great rapidity. There was a moderate honey flow; the average was 2.7 pounds per day, table 1. Absolute humidity was only slightly lower than that in series II. But the temperature averaged 90.4 degrees F. for the period, 13.9 degrees higher than that of series II. For 5 to 6 hours each day the thermometer read above the 100-degree mark and reached 104 degrees F. every afternoon. These high temperatures with their effects on relative humidity and the ventilating activity of the bees account for the rapid rate of ripening.

Very little difference in ripening is shown between combs of series III. Comb *A* with reduced ventilation required only 18 hours longer to ripen than comb *C*. This suggests that even the least degree of ventilation tested was adequate under the conditions, in which case all combs would ripen at about the same rate as was observed.

A comparison of weather and honey flow records for the three series shows that the data may be regarded as a cross section of the typical Iowa honey produc-

ing seasons; the differences between the three series show the variability of conditions. Park found that honey ripened in the combs in 3 days. Though he presents no data concerning honey ripening factors, his results seem to demonstrate a set of conditions comparable to series II of the present work; while series I approaches one extreme and series III the other.

The present work might appear to conflict with Hambleton's observations. Nocturnal loss represents only a part and probably a lesser part of the honey ripening process. In addition, nocturnal loss represents a combination of other factors not connected with the honey ripening process. Hence the true relationships of weather, net gain and nocturnal loss to the honey ripening process tended to be obscured. It must be kept in mind that the ripening of honey proceeds at a rapidly diminishing rate as the vapor pressure of the honey approaches equilibrium with the moisture of the air in the hive. Honey which appears to be nearly ripe may require a long period to attain ripeness. The author agrees with Hambleton that temperature and relative humidity have apparently a minor effect on honey ripening unless the outside temperature is greater than that within the hive. If air is heated to a more or less constant temperature after passing into the beehive, absolute humidity should show a more marked effect than relative humidity. Comb *A*, series I, seems to illustrate the effect of absolute humidity. The results presented here are not perfectly comparable to Hambleton's work because of regional and climatic differences and the fact that in the present work the bees did not have access to the ripening honey. It is known that bees remove green honey from the comb and ripen it further by manipulation; however, the extent and importance of this phenonenon to the honey ripening process have not been determined.

Because increased ventilation had little effect on ripening in series III is no reason for ignoring ventilation when similar conditions occur. Beekeepers have found special ventilation useful in swarm control and also in prevention of loafing and clustering during hot weather.

The results of this experiment show that a honey ripening problem actually exists. Series I demonstrates that a condition may not be uncommon in which green honey reaches a point of equilibrium with other conditions and ceases to ripen as long as those conditions continue. When the observed conditions were most favorable for honey production they were least favorable for honey ripening. Under those same conditions increased

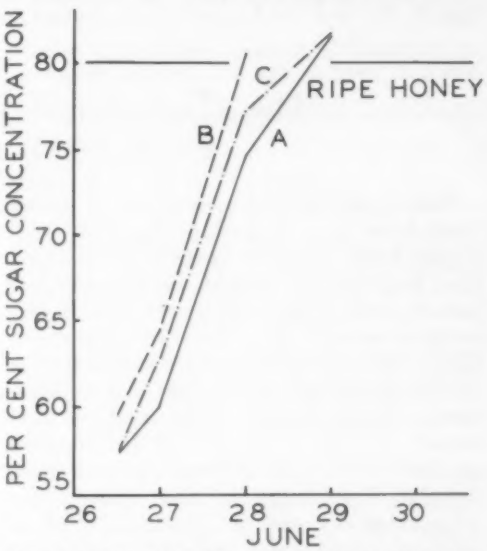

FIG. 3.—Rate of ripening for combs of series III, June 26 to 30, 1933. Comb *A*, reduced ventilation; comb *B*, normal ventilation; comb *C*, normal ventilation plus one-half inch crack below top story.

ventilation was most effective in speeding up and completing the honey ripening process. Whether ventilation is always an effective compensator when other ripening conditions are unfavorable remains to be seen. Further investigation and actual practice are to be desired in solving this problem.

CONCLUSIONS.—Conclusions drawn from this experiment are as follows:

1. Special provision for upward ventilation was effective in speeding up and completing the ripening of honey under conditions of mild weather and an abundance of nectar.

2. Special ventilation is of little value to the honey ripening process when weather is hot and excessively dry or the honey flow is slight.

3. Temperature, humidity and the character of the honey flow are important factors in the rate of honey ripening and they determine whether special provisions for ventilation are of any effect on the speed of the honey ripening process.—1-6-39.

LITERATURE CITED

Greenleaf, W. C. 1933. Fermented honey. Am. Bee Jour. 73: 436.
Hambleton, J. I. 1925. The effect of weather on the changes of weight of a colony of bees during the honey flow. U. S. Dept. Ag. Dept. Bul. 1339.
Jessup, J. G. 1925. Ventilation of the bee colony. Ia. State Apiarist's Rep. 1924: 35–7.
Park, O. W. 1925. The storing and ripening of honey by the honeybee *Apis mellifera*. JOUR. ECON ENT. 18: 405–10.
Park, O. W. 1928. Further studies on the evaporation of nectar. JOUR. ECON. ENT. 21: 882–7.
Park, O. W. 1932. Studies on the changes in nectar concentration produced by the honeybee *Apis mellifera*. Part I. Iowa Ag. Exp. Sta. Res. Bul. 151.
Park, O. W. 1933. Studies on the rate at which honeybees ripen honey. JOUR. ECON. ENT. 26: 188–93.

The Hygroscopic Properties of Honey

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Water absorptive properties of many foods have been studied, particularly with regard to the relative humidities at which they may best be stored. Beekeepers and honey packers are well aware that honey is hygroscopic. The fact that honey of high moisture content is more susceptible to fermentation than honey of low moisture content makes it imperative that water absorption by honey be guarded against in all stages of production. A more definite knowledge of the hygroscopic properties of honey is fundamental to an understanding of ripening conditions within the hive, proper extracting and proper storage.

Browne (1922) studied the moisture absorptive powers of different sugars and other carbohydrates, including honey, and found that, of the various substances investigated, starch absorbed moisture most readily, but levulose was most retentive of its moisture. Waters (1923) subjected films of honey to varying atmospheric humidities and concluded that honey adjusts its moisture content to that of the atmosphere by which it is surrounded. Lothrop (1937) investigated the ability of honey to absorb and to retain moisture as a basis for the utilization of honey for industrial purposes. Cakes in which the various honeys were used showed better moisture retaining qualities than those containing other sugar sirups, with the exception of levulose sirup.

Fabian & Quinet (1928) report that 21 per cent moisture content seemed to be the critical point for fermentation to begin in a group of 21 honey samples. Extracted honey stored at a relative humidity of 100 per cent increased in weight as much as 32.99 per cent. Comb honey was also found to absorb moisture in a saturated atmosphere.

Honey in the previously mentioned experiments was exposed in thin films and no evidence is given as to what extent moisture changes penetrate into a mass of honey. The present work was undertaken to study the responses in different depths of honey, both in the liquid and crystallized form, when exposed to various relative humidities; that is, to determine to what extent hygroscopicity is a surface phenomenon and to what extent moisture disperses through the honey, altering the water content and thereby affecting the storage and in some localities the grading problem.

METHODS.—To get data on the response of honey to different relative humidities, chambers were prepared in which different relative humidities were maintained, and in which honey samples of various depths were exposed in both liquid and granulated form. When in use the chambers were effectively sealed and were kept at a fairly constant temperature of 20 degrees C. Relative humidity in these chambers was controlled chiefly by means of aqueous solutions of certain salts with considerable excess of undissolved salt kept in a closed limited space.

The solutions of various salts were placed in the chambers and the honey samples exposed on screens above them. Table 1 gives the relative humidities employed and the agents used to attain them.

Samples of liquid honey were placed in glass evaporating dishes of fairly uniform construction, 35 millimeters in diameter,

* The writer is indebted to Dr. E. F. Phillips for guidance throughout the course of this investigation, and for assistance in the preparation of this paper.

the surface area varying from 850 to 880 square millimeters. Honey was used in depths of 7, 14, 21, 28 millimeters. A trace of sodium benzoate was added to samples in the higher relative humidities, as a preservative. Clover honey was used, the original water content being 17.4 per cent. Samples were weighed periodically to 0.0001 gram.

Crystallized honey samples were exposed in a duplicate series of relative humidities. The honey was obtained by agitating firmly granulated honey until it was soft enough to transfer to beakers approximately 42 millimeters in diameter. The honey was clover honey with an original moisture content of 16.2 per cent.

To determine the rapidity with which moisture may be absorbed through honey cappings, a section of comb honey was placed at 81 per cent relative humidity. The wooden section surrounding the comb was covered with beeswax to prevent absorption of moisture.

To compare the relative hygroscopicity of dextrose and levulose, a crystalline sample of each sugar was exposed for approximately a week in each of a series of relative humidities from 20 per cent to 81 per cent. Percentage increase in moisture was computed from weighings.

RESULTS.—The percentage of water in the honey samples was calculated from each weighing and these percentages are shown for liquid honey in table 2. Tables for crystallized honey are not included. The liquid honey containing 17.4 per cent moisture was at equilibrium at 58 per cent relative humidity; that is, the amount of water given off at the surface of the honey equalled that being absorbed. Honey samples at 66, 76 and 81 per cent relative humidities were approaching equilibrium between the water content of the honey samples and the relative humidity of the atmosphere at the close of observations. It was not possible to continue the experiment until all the samples reached equilibrium.

Honey exposed to high relative humidity absorbs water rapidly. The water content of liquid honey sample *a* exposed to nearly 100 per cent relative humidity increased 1.08 per cent per day for 20 days. In a period of less than 3 months this sample increased in weight 84.4 per cent, the sample containing 55.2 per cent moisture at the close of observations. In all samples the rate of water exchange became progressively slower as time of exposure continued. Where moisture is being lost, a dry film forms on the surface of the honey, which retards diffusion and loss of moisture. Loss of water from ripe honey at low relative humidity is usually slower than gain of water at high relative humidity. Moisture loss from honey samples at approximately 0 per cent relative humidity was less rapid than at 20 per cent relative humidity.

Table 1.—Relative humidities employed in the experiment and the agents used to attain them.

PER CENT RELATIVE HUMIDITY	AGENT	
0.0	$CaCl_2$ anhydrous	
20.0	$KC_2H_3O_2$	supersaturated solution
32.3	$CaCl_2 \cdot 6H_2O$	supersaturated solution
42.0	$Zn(NO_3)_2 \cdot 6H_2O$	supersaturated solution
52.0	$NaHSO_4 \cdot H_2O$	supersaturated solution
58.0	$NaBr \cdot 2H_2O$	supersaturated solution
66.0	$NaNO_2$	supersaturated solution
76.0	$NaC_2H_3O_2 \cdot 3H_2O$	supersaturated solution
81.0	$(NH_4)_2SO_4$	supersaturated solution
90.0	$ZnSO_4 \cdot 7H_2O$	supersaturated solution
100.0	Distilled water	

The rate of change in percentage water content varied inversely with the depth of honey, while the amount of water change varied directly with the depth, showing that water absorption or loss is a surface phenomenon. The gain or loss of water is transmitted through the mass of honey by diffusion to or from the lower depths. Theoretically, all samples in each chamber would eventually contain the same percentage of moisture.

Crystallized honey samples exposed to relative humidities of 81 per cent and higher liquefied gradually from the surface downward. These samples increased in water content at the surface until presumably no dextrose remained in excess of saturation. Liquefaction continued as the moisture diffused downward. When complete liquefaction occurred, the samples contained between 35 and 40 per cent moisture, which is roughly the same as the percentage of dextrose in most honeys. None of the crystallized honey samples reached equilibrium. Water exchange in crystallized honey is apparently slower than in liquid honey.

The comb-honey section was exposed

Table 2.—Per cent water in liquid honey samples at various weighings. Approximate original depth of honey exposed: a, 7 millimeters; b, 14 millimeters; c, 21 millimeters; d, 28 millimeters.

Relative Humidity	Sample	Date											
		Dec. 9	Dec. 14	Dec. 19	Dec. 23	Jan. 8	Jan. 12	Jan. 21	Feb. 10	Feb. 21	Mar. 2	Mar. 25	Apr. 2	Apr. 18
20 per cent	a	17.400	15.618	14.730	14.242	13.136	12.934	12.535	11.789	11.466	11.307	10.927	10.807	10.663
	b	17.400	16.552	15.967	15.644	14.729	14.546	14.213	13.473	13.141	12.980	12.577	12.449	12.289
	c	17.400	16.817	16.388	16.101	15.316	15.146	14.826	14.151	13.833	13.679	13.291	13.164	13.003
	d	17.400	16.971	16.647	16.422	15.765	15.616	15.317	14.975	14.667	14.515	14.133	14.008	13.847
		Dec. 10					Jan.14							
32 per cent	a	17.400	16.123	15.197	14.710	13.610	13.308	13.017	12.260	11.931	11.772	11.387	11.275	11.130
	b	17.400	16.676	16.020	15.645	14.705	14.437	14.164	13.439	13.099	12.946	12.547	12.423	12.275
	c	17.400	16.922	16.475	16.166	15.369	15.120	14.863	14.182	13.868	13.710	13.321	13.197	13.046
	d	17.400	17.055	16.701	16.472	15.804	15.593	15.370	15.041	14.744	14.590	14.208	14.087	13.931
		Dec. 9	Dec. 13					Jan. 22						
42 per cent	a	17.400	16.083	15.110	14.653	13.632	13.365	13.044	12.436	12.152	12.032	11.843	11.695	11.619
	b	17.400	16.686	16.023	15.667	14.780	14.516	14.204	13.587	13.285	13.145	12.805	12.720	12.600
	c	17.400	16.905	16.401	16.120	15.350	15.109	14.820	14.228	13.929	13.784	13.427	13.329	13.195
	d	17.400	17.035	16.621	16.390	15.699	15.500	15.227	14.669	14.381	14.237	13.884	13.778	13.645
						Jan. 9								
52 per cent	a	17.400	17.274	17.198	17.162	17.146	17.123	16.887	16.536	16.397	16.360	16.247	16.169	16.168
	b	17.400	17.333	17.296	17.274	17.216	17.184	17.040	16.726	16.591	16.489	16.370	16.275	16.236
	c	17.400	17.356	17.315	17.288	17.238	17.206	17.092	16.816	16.686	16.630	16.459	16.374	16.327
	d	17.400	17.363	17.330	17.307	17.266	17.243	17.144	16.895	16.771	16.715	16.536	16.460	16.409
		Dec. 8						Jan. 23						
58 per cent	a	17.400	17.471	17.484	17.519	17.735	17.735	17.739	17.544	17.425	17.446			
	b	17.400	17.418	17.446	17.441	17.533	17.533	17.540	17.453	17.364	17.372			
	c	17.400	17.418	17.438	17.429	17.494	17.494	17.494	17.395	17.326	17.332			
	d	17.400	17.411	17.425	17.419	17.465	17.465	17.464	17.380	17.323	17.323			
66 per cent	a	17.400	18.201	18.804	19.105	20.222	20.385	20.611	20.728	20.662	20.698	20.722	20.637	20.663
	b	17.400	17.753	18.049	18.176	18.712	18.814	18.973	19.220	19.372	19.494	19.760	19.818	19.978
	c	17.400	17.690	17.891	17.984	18.379	18.451	18.570	18.750	18.851	18.943	19.147	19.193	19.328
	d	17.400	17.618	17.781	17.847	18.153	18.207	18.306	18.440	18.512	18.578	18.735	18.767	18.875
					Dec. 22									
76 per cent	a	17.400	19.811	21.568	22.351	25.562	26.034	26.598	27.094	27.137	27.322	27.389	27.347	27.607
	b	17.400	18.743	19.730	20.179	22.249	22.702	23.391	24.595	25.177	25.585	26.312	26.495	26.900
	c	17.400	18.317	18.981	19.270	20.652	20.942	21.396	22.280	22.747	23.120	23.914	24.255	24.680
	d	17.400	18.268	18.835	19.077	20.236	20.471	20.844	21.535	21.908	22.213	22.852	23.058	23.506
		Dec. 7		Dec. 18										
81 per cent	a	17.400	21.230	23.112	24.416	28.466	29.079	30.660	31.064	31.537	31.747	32.087	32.082	moldy
	b	17.400	19.696	21.022	21.846	24.834	25.492	26.572	28.496	29.348	29.889	30.967	31.195	31.575
	c	17.400	19.178	19.994	20.544	22.614	23.048	23.846	25.352	26.159	26.747	28.087	28.702	29.115
	d	17.400	18.903	19.573	20.030	21.739	22.102	22.751	24.020	24.705	25.181	26.359	26.695	27.264
					Jan. 9	Jan. 14	Jan. 23	Feb. 9	Feb. 20	Feb. 27	Mar. 12			
90 per cent	a	17.400	20.656	24.414	32.613	33.448	34.675	35.220	17.360	23.815	30.975	35.111	36.931	39.127
	b	17.400	20.411	23.520	29.531	30.590	32.400	35.389	17.360	21.292	25.951	29.534	31.610	34.474
	c	17.400	20.470	22.148	26.695	27.465	28.801	31.023	17.360	20.506	24.178	27.009	28.657	30.943
	d	17.400	20.244	21.770	25.978	26.641	—over	flowed						
		Dec. 1	Dec. 6	Dec. 13	Dec. 18	Dec. 22	Jan. 22							
100 per cent	a	17.400	27.820	35.409	39.418	42.111	17.380	37.636	43.680	45.941	49.319	51.857	53.152	55.201
	b	17.400	22.771	27.650	30.755	33.097	17.380	30.413	35.848	38.322	42.312	45.427	47.146	49.692
	c	17.400	21.477	25.370	27.851	29.822	17.380	27.718	32.352	34.532	37.967	40.582	—over	flowed
	d	17.400	21.413	25.304	—over	flowed								
									Mar. 6	Mar. 13	Mar. 20	Mar. 27	Apr. 17	May 2
0 per cent	a								17.400	16.119	15.315	14.705	13.825	13.253
	b								17.400	16.738	16.227	15.797	15.072	14.564
	c								17.400	16.897	16.491	16.132	15.509	15.068

* Samples fermented and dishes refilled.

for 35 days at a relative humidity of 81 per cent. During this time the section gained 8.5 grams in weight, which represents an increase of 2.01 per cent of the total weight of the section. The crystalline dextrose sample increased 7.17 per cent of the original weight. The crystalline levulose, under the same humidity conditions as dextrose, deliquesced entirely and increased 36.17 per cent of the original weight.

CONCLUSIONS.—Following are the conclusions:

1. Honey exposed to air tends to establish equilibrium in water content with the water vapor of the atmosphere, at first rapidly and then more slowly as equilibrium is approached.

2. Exchange of moisture between honey and the air is a surface phenomenon, but the change in water content slowly occurs throughout the honey by diffusion.

3. In a dry atmosphere as moisture is lost at the surface of honey a shining dry film is formed which retards subsequent water changes in the honey, so that in a

dry atmosphere moisture changes occur more slowly than in moist atmospheres.

4. There is apparently an optimum relative humidity for drying honey which is not 0 per cent relative humidity. This point was not determined exactly, but is apparently somewhere between 0 per cent and 20 per cent relative humidity.

5. While in the crystalline form honeys change moisture content more slowly than do liquid honeys, but when crystalline honey is exposed in a moist atmosphere there is a steady liquefaction of the dextrose crystals.

6. Liquid honey of 17.4 per cent water content is in equilibrium with the water vapor in an atmosphere of 58 per cent relative humidity, while crystalline honey tends to attain equilibrium at a slightly higher relative humidity. For best honey storage conditions, the relative humidity of the atmosphere should not be over 60 per cent.

7. Moisture exchange will occur through the capping of honey sealed in the comb.

8. Dextrose is slightly hygroscopic and levulose highly hygroscopic. The hygroscopic qualities of honey are apparently due chiefly to the levulose content, although other ingredients play some part. —1-6-39.

LITERATURE CITED

Browne, C. A. 1922. Moisture absorptive powers of different sugars and carbohydrates under varying conditions of atmospheric humidity. Jour. Ind. and Eng. Chem. **14**: 712–4.

Fabian, F. W., and R. I. Quinet. 1928. A study of the cause of honey fermentation. Ag. Exp. Sta. Mich. St. Col. Tech. Bul. 92.

Lothrop, R. E. 1937. Rentention of moisture in honey. Am. Bee Jour. **77**: 281. June.

Waters, R. 1933. Honey and atmospheric moisture. New Zealand Jour. Ag. **26**: 105–07.

Comparative Value of Pollen and Pollen Substitutes

*I. Bee Bread and Cottonseed Meal–Dry Skim Milk Mixture**

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In the previous articles on the value of pollen substitutes (Haydak 1933, 1936, 1937) the author has paid attention almost exclusively to the question of whether any given food substance can replace pollen as a food for bees. Little emphasis has been placed on the exact comparative value of pollen and pollen substitutes studied, except in the first publication. From those investigations an impression might have been gained that those substances which bees can utilize as food are inferior to pollen as stored by the bees. One has to remember, however, that the control colonies in the previous experiments were given bee bread in a natural undiluted state, while the experimental colonies were given mixtures of the dry food and honey in proportion 1:4 to 1:7. Under such circumstances the qualitative and quantitative differences which were observed in the experiments might have been due to the fact that the bees fed pollen actually consumed more food per volume intake than did the bees fed pollen substitutes and therefore showed a better physiological performance.

For an evaluation of the nutritive value of any food substance the food intake of the experimental animals must be equalized. In case of bees where any restriction in food brings a certain reaction of the colony as a whole (restriction of egg laying, change in the rate of brood rearing activity), such equalization may bring additional factors which may make very difficult the interpretation of the results obtained. Therefore it was decided to feed the experimental colonies *ad libitum*, but to equalize the percentage of food per volume intake. The amount of food given to the experimental colonies was noted.

METHODS.—The method and the procedure of the present experiment did not substantially differ from those described previously (Haydak 1937). It was found, however, that an addition of a laying queen during the first day simultaneously

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with the second brushing of emerged bees into the experimental hive tends to quiet the bees and makes the whole procedure of an addition of new bees simple and easy. Young bees were not brushed directly into the hive, but into a glass container through a bee funnel, similar to that which is used in the bee package industry. The container with the bees was then weighed and the bees poured into the hive. In such a way the number of bees in the colonies was to a certain degree equalized.

Since it was established that the growth experiment. Except for the percentage of mortality, only the average of two colonies was used. This was done because one colony in each group did not rear brood. One of the colonies fed bee bread–honey mixture did not start brood-rearing although for 27 days eggs were present in the cells. Bee bread of 1933 was used for the food mixture. Another colony which was simultaneously fed bee bread of the same age from the same jar started brood-rearing and carried it to completion. In this case the bee bread was mixed with commercial invert.

Table 1.—Composite results of feeding bee bread and cottonseed meal–dry skim milk mixture.

Food	Total Number of Bees	Development of Bees (Weight of Thoraces in Milligrams)					Percentage Mortality	Food Consumption in Grams	Number of Days in Which Brood Rearing Started After Queen Was Added	Number of Sealed Cells and Larvae Before Sealing	Dry Weight of Emerging Bees in Milligrams
		Emerging Bees	2 Days Old	4 Days Old	5 Days Old	8 Days Old					
Bee bread	8,459	9.1	11.4	12.0	13.0	13.3	25.6	666	13	321	15.3
Cottonseed meal–dry skim milk food	9,608	9.1	10.9	11.8	12.6	13.2	33.6	490	9	391	15.5

curves representing the increase in the dry weight and nitrogen content for adequate foods follow each other quite closely (Haydak 1937), only the dry weights of the thoraces of the experimental bees were ascertained.

FOODS.—Clumps of bee bread as taken from the cells of a comb were used; 50 grams of bee bread were mixed with 20 cubic centimeters of water to make a paste; then 200 grams of honey were added and all the ingredients were thoroughly mixed in a mortar. Bee bread of 1933 (5 years old) and of 1937 (1 year old) was used in the experiment. Both samples were stored in a refrigerator.

Sifted cottonseed meal was mixed with dry skim milk (spray process) in the ratio 4:1 by weight. Forty grams of this mixture were mixed with 200 grams of honey, and 20 cubic centimeters of water were incorporated into the mixture. The dry weight of both foods was the same.

Foods were distributed to the cells of a comb and given to the experimental colonies in the usual manner. Three colonies were used for the testing of each food. One colony in each group received a dry food–commercial invert mixture (*Nulomoline* brand).

RESULTS AND DISCUSSION.—Table 1 gives a summary of the results of the

The cottonseed–commercial invert fed colony did not start brood-rearing, although for 21 days eggs were present in the colony. In both cases fertile queens whose good performances in the colonies have been known were used. It is hard to explain these fact on the basis of our present knowledge of bee life.

Examination of the table shows that there was practically no difference in the results obtained. The development of the bees proceeded normally. The behavior of all the colonies was about the same. The brood-rearing activity was started several days later in the pollen-fed colonies and the consumption of food in the latter was higher than that in the pollen substitute-fed colonies. However, the average mortality in the latter group was somewhat greater. In neither group did the brood cells form a compact mass. In this case pollen-fed colonies differed considerably from those in the preceding experiment when the sealed brood cells in the pollen-fed colonies formed a compact mass as under natural conditions (Haydak 1937). The young bees reared by the experimental colonies were of almost the same weight. However, their weights were lower than those of the young bees in the previous experiments.

When combs with sealed brood were re-

moved from the experimental colonies, the bees continued their brood-rearing activities without an interruption as they would do under normal conditions.

SUMMARY AND CONCLUSION.—A comparison has been made between the pollen as stored by bees in the cells and cottonseed meal–dry skim milk mixture. The food was prepared in such a manner as to make the ingestion of pollen and the food substance investigated equal per volume intake. Three colonies have been used for the testing of each food. One colony in each group did not start to rear brood at all. No adequate explanation has been found for this phenomenon. The rest of the colonies started brood-rearing and carried it to completion.

The results of the experiment indicated that there was practically no difference in the nutritive value of the bee bread and the cottonseed meal–dry skim milk mixture as judged by the development of bees, number and quality of the bees reared and the mortality of the experimental bees.—1-6-39.

LITERATURE CITED

Haydak, M. H. 1933. Der Nahrwert von Pollenerzatzstoffen bei Bienen. Arch. f. Bienenkunde, **14**: 185–219.

Haydak, M. H. 1936. Value of foods other than pollen in nutrition of the honeybee. JOUR. ECON. ENT. **29**(5):870–7.

Haydak, M. H. 1937. Further contribution to the study of pollen substitutes. JOUR. ECON. ENT. **30**(4):637–42.

Variations in the Size of Wings of Some Massachusetts Honeybees

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That the wings of honeybees are very important factors in their success as honey gatherers and as pollinators is a self-evident fact, and any effort to improve the honeybee or to develop the New Bee, as suggested by Dr. Watson, should give these organs careful consideration. One of the first problems to be solved is whether or not there is a definite variation in the mean size of wing of different colonies and, if such a variation exists, to determine its extent.

With this problem in view, studies were made on 863 honeybees, taken from 17 different colonies in the apiary of Massachusetts State College: 207 Italian bees from five different hives, 309 Caucasion bees from six different hives and 347 Carniolan bees from six different hives. The length and width of the wings of each bee, taken from the right side, were measured with a micrometer eyepiece and the area of the wings found by multiplying the length by the width and taking one-half the result [Area = L × W /2] on the grounds that the wing is roughly a triangle in shape and that this formula would give approximately the area. While such figures are admittedly not exactly correct for the absolute area of each wing, areas of all wings are computed in the same manner and this makes possible a comparison between different colonies of bees which, after all, is what we desire.

An examination of the means of wing areas from the 17 colonies shows that there is a definite mean for wing size in each colony and that the means vary considerably, the greatest mean area of wing being 7.6 per cent greater than the smallest mean area of wing. It is interesting to note, although not necessarily significant, that both extremes of wing area are found among the Caucasian colonies.

While the number of colonies considered is insufficient to make possible any definite conclusions concerning comparative wing areas to be found in the three races, it might be noted that in this small series of colonies the Italian colonies varied the least (4.2 per cent), the Caucasian colonies varied the most (7.6 per

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Table 1.—Wing variation in some Massachusetts honeybees.

Type and Specimen		Fore Wing			Hind Wing			Total Area†
		Length*	Width*	Area†	Length*	Width*	Area†	
Italian	1	9.952	3.324	16.5402	7.119	1.924	6.8484	23.3886
	2	9.768	3.337	16.2979	7.100	1.945	6.9047	23.2026
	3	9.770	3.272	15.9837	7.002	1.890	6.6169	22.6006
	4	9.704	3.277	15.9000	6.972	1.877	6.5432	22.4432
	5	9.795	3.324	16.2793	7.052	1.912	6.7417	23.0210
Mean		9.789	3.307	16.1861	7.049	1.910	6.7318	22.9174
Caucasian	1	9.948	3.338	16.6032	7.147	1.912	6.8325	23.4357
	2	9.872	3.299	16.2838	7.112	1.879	6.6817	22.9655
	3	9.585	3.212	15.3935	7.035	1.849	6.5038	21.8973
	4	9.598	3.265	15.6687	6.895	1.869	6.4433	22.1120
	5	9.756	3.288	16.0388	7.046	1.910	6.7289	22.7677
	6	9.676	3.188	15.4235	7.017	1.796	6.3462	21.7697
Mean		9.752	3.273	15.9591	7.043	1.872	6.5922	22.5513
Carniolan	1	9.785	3.286	16.0767	7.050	1.961	6.9125	22.9892
	2	9.577	3.253	15.5770	6.820	1.922	6.5540	22.1310
	3	9.666	3.301	15.9537	6.899	1.975	6.8127	22.7664
	4	9.846	3.338	16.4329	6.994	1.949	6.8156	23.1998
	5	9.584	3.245	15.5500	6.799	1.910	6.4930	22.0431
	6	9.687	3.285	15.9109	6.789	1.914	6.4970	22.4079
Mean		9.708	3.284	15.9405	6.878	1.936	6.6579	22.5984

* Millimeters.
† Square millimeters.

cent), while the variation between the extreme means in the Carniolan colonies was 5.2 per cent.

The table of means given in table 1 shows the variation in colony means for wing length, width and area for both the fore and hind wings and also for total wing areas of the 17 colonies.—1-6-39.

The Sugar Concentrations of Western Nectars

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During the past several seasons miscellaneous data showing the concentration of sugars in western nectars have been recorded. Although humidity and air movement have an important influence on concentration, under any given atmospheric condition the concentrations in different plants are different. Not only have the nectars from different species been shown to vary but those from the varieties within a species as well. Table 1 illustrates the situation in a plum orchard in which trees of different varieties grew side by side, and table 2 shows the nectar concentrations found in several species of vetch. The process whereby the sap of a maple tree, for example, which has a sugar content of 2 to 3 per cent attains a concentration of 50 per cent or higher in

Table 1.—Sugar concentrations of nectar from several varieties of plum at Davis, Calif., on the morning of March 17, 1935.

Variety of Plum	Average Sugar Concentration of Sample, Per Cent	Average Number of Blossoms Required for Sample
Maynard	10.1	8
Gee Whiz	13.5	12
Eldorado	14.9	15
Miss Edith	16.1	18
Shiro	17.8	12
Etta	19.0	15
First	23.3	15
Milton*	28.4	20
Kelsey†	—	—
Better Than Gold†	—	—
Kingdom Come†	—	—

* Outstanding variety as to number of bee visitors.
† Nectar insufficient for hand collection. Bees entirely absent.

Table 2.—Sugar concentrations of nectar from blossom and extrafloral nectaries* of several species of vetch, Oregon, June, 1937.†

SPECIES OF VETCH	LOCALITY	SOURCE OF NECTAR‡	SUGAR CONCENTRATION, PER CENT	REMARKS
Common	Corvallis	Blossom	22.6	
		Stipular	56.5	
Hairy	Corvallis	Blossom	44.0	Stipular nectar practically absent
Hungarian	Corvallis	Blossom	25.2	No bees were observed to work blossoms of this vetch
		Stipular	47.7	
Melamops	Corvallis	Blossom	22.6	
		Stipular	52.1	
Purple	Junction City	Blossom	28.0	
Wild	Fort Klamath	Blossom	23.1	Bees displayed no interest in this vetch

* Where the extrafloral nectaries produced, the honeybees confined their activities to this source almost exclusively.
† Records were obtained during daylight hours, and the figures represent averages of numerous readings taken at various times during the day.
‡ All the samples of stipular nectar and the blossom nectar of hairy vetch were obtained from the nectar sacs of the bees; the other blossom nectars were collected by hand.

Table 3.—Average sugar concentrations of the nectars of some western plants.*

NAME OF PLANT	AVERAGE SUGAR CONCENTRATION, PER CENT	REMARKS
Filaree, red	65.0	
Locust, black	63.2	
Willows, several	60.0	
Astragalus packypus	59.2	
Wild buckwheat, flat top	58.1	Southern California
Sainfoin	55.4	
Bachelor button	52.5	
Bigleaf maple†	52.0	
Wild alfalfa (*Lotus glaber*)	52.0	
Sweetclover, yellow	51.6	
Dandelion	51.2	
Mustard, rape	50.5	
Wild buckwheat, annual pink	50.5	Eastern Oregon
Apples, several	50.0	
Chickweed	50.0	
Mustard, common	50.0	
Cherry, sweet	50.0	
Flax	49.5	
Buckeye, Ohio	49.0	Planted at Corvallis, Ore.
Hoarhound	48.3	
Sage, white	48.0	
Castor-bean	47.8	Extrafloral nectar
Vetch, Hungarian	47.7	Oregon, extrafloral nectar
Clover, crimson	47.7	
Sunflower, perennial	45.8	Oregon
Hollygrape, Oregon	45.0	
Sage, black	44.9	
Mustard, Jim Hill	44.1	
Clover, alsike	43.3	
Astragalus hornii	42.4	
Maple,† vine	42.0	
Cotton, Acala	41.9	Extrafloral nectar
Buckeye,‡ California	41.5	Wide variation, 33-0-50.8
Alfalfas, several	41.1	California, Nevada and Oregon

* The figures given represent aggregate averages of a long series of observations primarily in Oregon, California and Nevada.
† The maples with open-type blossoms show a very wide range in nectar concentration with changing humidity conditions. They were invariably rich enough to be very attractive under all conditions good enough for bees to be in the field.
‡ Ruth Beutler in Germany reports red buckeye with a sugar concentration of 66 per cent.

Table 3 (continued)

NAME OF PLANT	AVERAGE SUGAR CONCENTRATION PER CENT	REMARKS
Clover, white, ordinary, and ladino	41.0	
Manzanitas, several	40.0	
Spikeweed	39.9	
Privet	39.2	
Wild buckwheat, annual pink	37.8	California
Star-thistle, yellow	37.5	
Pentstemon	37.3	
Wild buckwheat, yellow perennial	37.3	Eastern Oregon
Milkweed	37.2	
Sweetclover, white	35.8	
Blackberry, evergreen	35.6	
Thistle, Canadian	35.0	
Linden, American	33.6	Oregon
Astragalus hendersonii	33.3	
Clover, strawberry	33.3	
Fenugreek	32.9	
Sage, creeping	32.4	Eldorado County, Calif.
Monkey plant	32.0	
Sunflower, annual	31.6	
Eucalyptus rostrata (red gum)	30.0	
Orange, navel	30.0	
Peaches, several	30.0	
Catnip	28.7	
Snowberry	28.6	
Blackberry, Himalaya	27.2	
Blue curl	27.1	
Astragalus trichopodus	27.0	
Tree tobacco	25.9	
Vetch, Hungarian	25.2	Oregon, floral nectar
Turkey mullein	25.0	
Cleome serrulata	21.9	
Cotton, Acala	21.5	Floral nectar
Scrophularia sp.	19.6	Oregon, California
Tulip poplar	19.6	
Currant, flowering	18.9	
Avocado	15.2	Southern California
Cherry, sour	15.0	
Eucalyptus, small-blossom variety	13.4	May, southern California
Apricots, several	12.0	
Cleome lutea	11.0	
Madrone	10.0	
Pear, several	4.0–30.0	

the nectar is apparently an enigma to science.

The average sugar concentrations in the nectar of 76 plants are compiled in table 3. Although it would probably not be possible to obtain these exact figures in another series of field records on the same kinds of plants, these data represent an index for arrangement of the plants as to their theoretical honey value irrespective of nectar quantity, although abundance of nectar is undoubtedly a very important factor in a practical measure of value.

The concentration records were obtained through the use of a sugar refractometer, without temperature correction. Nectar was either collected from the blossoms by pipette or taken from the honey sacs of the bees that were visiting the blossoms for nectar.—1-6-39.

Collecting Red Clover Pollen by Honeybees

W. E. DUNHAM, *U. S. Department of Agriculture** and *Ohio Experiment Station*

A quantitative analysis has been attempted on the amount of pollinating activity performed by honeybees on red clover in one of the important seed growing areas of the state.

The fact that honeybees devote practically all their time to gathering pollen from red clover bloom and that practically no nectar is gathered suggested the possibility of diagnosing the extent of pollinating activity of individual honeybees on the basis of pollen counts. Accordingly the following phases of experimental work were undertaken: a determination of the number of pollen grains in unpollinated and pollinated florets of red clover; and the number of red clover pollen grains per pellet collected by a honeybee.

DETERMINING NUMBER OF RED CLOVER POLLEN GRAINS IN COROLLAS.—Individual red clover heads were covered with cheesecloth before blossoming to exclude pollinating insects. When each clover head was in full bloom it was examined closely and individual florets were plucked from different heads. Immediately after these unpollinated florets were obtained, the clover heads, from which the unpollinated florets had been obtained, were taken to a large cage containing a colony of honeybees. The clover head was held in the cage until a honeybee was observed working on an individual floret, after which it was removed. The procedure was repeated until the desired number of pollinated florets was obtained. Both the unpollinated and pollinated florets were placed in small envelopes and stored for counting during the winter.

The following method was worked out in 1931 for determining the number of pollen grains contained within a single flower of red clover. With a fine pair of scissors the upper half of the corolla was snipped off and placed in a LaMotte pH cell to which 3 drops of an alcohol-glycerine solution containing a brilliant green stain was added. The cell was then placed under a low power binocular and by means of two fine probes made with minuton pins the corolla was teased about until the pollen grains clinging to the anthers were dislodged. During an interval of 20–30 minutes the pollen grains became well stained with the brilliant green; and the corolla itself became nearly transparent so that if any pollen grains were covered by the corolla they could still be counted easily. Two additional drops of glycerine were added and the contents of the cell thoroughly stirred by means of the fine minuton probes. The LaMotte cell was then placed on a microscope slide on the stage of a microscope and examined under medium power and by means of a stage micrometer the number of pollen grains counted in a known area, 1 square millimeter, were counted.

One count was made in each of 5 areas in the LaMotte cell and the average of these counts taken as representing the number of pollen grains in a given area, 1 square millimeter. The total number of pollen grains in a floret was obtained by multiplying the average number in 1 square millimeter by 79 (the area of the LaMotte cell is equivalent to 79 square millimeters).

* The Red Clover Pollination Project was initiated and supervised by James I. Hambleton, Principal Agiculturist, Bureau of Entomology and Plant Quarantine, and E. A. Hollowell, Senior Agronomist, Bureau of Plant Industry, U. S. Department of Agriculture.

DETERMINING NUMBER RED CLOVER POLLEN GRAINS PER PELLET.—A supply of red clover pollen pellets was obtained by catching incoming bees at the hive entrance and dislodging the pellets from the bees. These pollen loads were dislodged from the hind legs of each bee regardless of the size of the pellet in order that the pollen counts might give a representative index of the pollen loads brought in by honeybees. Loads of red clover pollen could be easily identified by the dark reddish-brown color. Microscopical examination when the pollen counts were being made showed that the pellets were practically pure red clover pollen.

The technique which was finally perfected and employed for determining the number of red clover pollen grains in pellets was as follows: Each pellet was first placed in a small test tube which was about $1\frac{3}{4}$ inches in length and five-sixteenths inches in diameter in which 4 drops of glycerine were placed. The pellet was usually left in the glycerine from 2 to 8 hours, since glycerine seemed ideal for softening the pollen pellets so the pollen grains could be separated from each other. By means of fine probes the pellet was stirred around in the glycerine until the pollen grains were evenly distributed. A solution containing 2 parts of 95 per cent alcohol and 1 part of glycerine was added until the small test tube was about half full. A stopper was then placed in the test tube and the test tube shaken rather vigorously. The contents were then poured into a tall test tube. The small test tube was rinsed out twice with the alcohol-glycerine solution. Enough additional solution was added to the tall test tube to bring the total volume to 2 cubic centimeters. To the alcohol-glycerine solution was added enough brilliant green to stain the pollen grains so that they could be easily distinguished when making microscopical counts.

A small amount of this solution containing the suspended pollen grains was placed on a Thoma counting chamber and the number of pollen grains determined in one-tenth cubic millimeter. Five such counts were made and an average of the 5 samples taken as a final number to represent the average number of red clover pollen grains in a given volume (one-tenth cubic millimeter). Then calculations were made to compute the number of pollen grains in 2 cubic centimeters in which the pellet had been placed.

RESULTS AND DISCUSSION.—In table 1 the results of the pollen counts are presented for unpollinated and pollinated corollas, and for pellet loads collected by honeybees. Of special interest are the relatively few pollen grains left in pollinated florets, which indicate the thoroughness of the honeybee in pollen collecting. This characteristic is especially valuable since in collecting the pollen many pollen grains will lodge in the serrate hairs on the under part of the thorax, thus increasing the effectiveness of the bee in cross-pollination when passing on to other blossoms of other red clover plants. As might be expected from the variation in the size of the pellets, the number of pollen grains in the pellets vary over a wide range.

Table 1.—Red clover pollen counts.

POLLEN COUNTS OF UNPOLLINATED COROLLAS	POLLEN COUNTS OF POLLINATED COROLLAS BY HONEYBEES	NUMBER OF POLLEN GRAINS PER PELLET	
		Honeybees	
1932	1932	1932	
1,185.0	142.2	160,000	140,000
1,169.2	189.6	180,000	112,000
1,121.8	31.6	172,000	212,000
900.6	205.4	132,000	208,000
948.0	79.0	172,000	180,000
1,232.4	173.8	144,000	196,000
837.4	173.8	128,000	204,000
1,437.8	221.2	100,000	216,000
1,406.2	47.4	100,000	312,000
1,058.6	110.6	132,000	272,000
1,437.8	189.6	112,000	256,000
1,074.4	363.4	148,000	200,000
916.4	47.4	208,000	228,000
1,532.6		81,000	160,000
1,042.8			
1,027.0			
1,279.8			
(TM ± SE)	(TM ± SE)	(TM ± SE)	
1,153.41 ± 50.73	148.08 ± 22.76	173,750 ± 10,410	

The minimum pollinating activity performed by a honeybee in collecting an average load of red clover pollen might be obtained by dividing the average number of pollen grains in a pellet by the number of pollen grains which the bee removed from the pollinated floret. Since a load of pollen represents two pellets, the above figure must be multiplied by 2, thus giving the approximate number of corollas which

the bee visited. In quantitative terms a honeybee in collecting an average load of red clover pollen visits approximately 346 florets.

Data obtained the same year on the rate of pollinating activity indicated that the honeybee visited approximately 12.5 red clover florets a minute. By dividing the total number of florets visited in collecting a pollen load by the rate of pollinating activity, a figure of 29.3 is obtained, which represents the number of minutes required to collect an average load of pollen.—1-6-39.

LITERATURE CITED

Gubin, A. F. 1929. The department of apiculture of Moscow district agricultural experiment station and its work on the role of the honeybee in pollination of agricultural plants. Transactions of the Fourth Int. Cong. Ent. 2: 960–3.

Holowell, E. A. 1932. Red-clover seed production in the intermountain states. U. S. Dept. Ag. Leaflet 93: 1–7.

Richmond, R. J. 1932. Red clover pollination by honeybees in Colorado. Colo. Ag. Exp. Sta. Bul. 391: 1–22.

Westgate, J. M., and H. S. Coe. 1915. Red-clover seed production: pollination studies. U. S. Dept. Ag. Bul. 289: 1–31.

Symposium on Extension Problems

What Are the Extension Problems in the Classroom Teaching of Entomology?

CLAY LYLE, *Mississippi State College, State College*

1. County agents should be trained in entomology to render the best service to their people and to cooperate intelligently with extension specialists in entomology, research workers in entomology and regulatory officials handling entomological problems.

2. The training of county agents in entomology can best be assured by the extension entomologist suggesting to his director of extension that he request the inclusion of entomology in the agricultural curriculum of the land grant college. The teachers are always ready to offer the subject, but are often not allowed to on account of the crowding of other subjects into the curriculum. The director of extension, however, is the employer, and his request that prospective agents receive any particular training would undoubtedly be granted by those preparing the curriculum.

3. The quality of the classroom training will depend largely on the interests of the teacher. A good teacher of economic entomology should be a good extension entomologist.

4. Students trained in schools where all phases of entomology—teaching, research, extension and regulatory—are in the same department under one head are more likely to be in constant touch with current entomological problems than are students in schools where these various phases are separate and distinct. In any school, however, the extension entomologist may render great assistance to the teacher by bringing in frequent reports of happenings in the field and interesting pictures or specimens, as well as in talking to the classes about the extension problems.—1-6-39.

What Are the Extension Problems in the Larger Insect Control Programs?

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In Maryland we have recently conducted two large-scale insect control programs, one a large-scale demonstration on salt marsh mosquito control, and the other on the retardation of the Japanese beetle.

During the mosquito work we cut 3,331,349 lineal feet of salt marsh ditches; constructed 10,500 lineal feet of dike, and constructed and installed 21 tide and spill gates.

Last year we began a large-scale Japanese beetle retardation program. To briefly outline this program, I might say that we had in use over the state last year over 40,000 traps which caught 123,166 quarts, or 615.85 barrels, of beetles. Traps were operated in 89 cities, towns and villages.

Demonstrational trapping was done in five heavily infested areas on farms. In the way of educational work we gave 159 illustrated lectures, 118 soil treatment demonstrations, exhibited at 15 fairs and distributed 80,000 circulars.

In conducting these campaigns, we have learned some of the problems in large insect control programs. From an extension viewpoint, perhaps our greatest problem in both of these programs was one of *education*. In the case of the mosquito work, the general public was very skeptical as to the feasibility of the project. For instance, the problem of obtaining easements on marsh land owned by duckers and muskrat trappers was very difficult. It was necessary for us to demonstrate, by the use of mosquito traps, and by way of diking muskrat marshes and in some instances fresh water ponds, before we were able to convince the public of the benefits derived from such work. However, after 2 years of hard work, both in the field and in educational campaigns the program has proved very successful.

In our Japanese beetle retardation program, which we are now conducting, the problem is to impress sufficiently the average citizen of the losses which are sustained in dollars and cents once the beetle is firmly established in a community, and in getting him to do something to prevent its establishment. We have been able to overcome this difficulty to a large degree by having good illustrative material and mainly by working with and through the younger people of our state. I mean by giving illustrated talks to civic clubs, high schools, garden clubs and especially to the F. F. A. organizations. Talks once a month for several months were given over radio station WBAL of Baltimore.

Another most effective method of putting across such a program, and one which cannot be overemphasized, is that of having an insect tour: gather interested people from each community throughout the state, tour the infested areas and show what is being accomplished.

In the case of the Japanese beetle, we have been able to get across to our people the necessity of fighting the beetle the minute one appears and not delaying until a severe infestation is built up. For instance, if one or two beetles are found in a town or community, we put up sufficient traps to be reasonably sure that any beetles left will be trapped. We believe such a program will retard the spread of this pest for at least 5 to 10 years and the money spent for such work will be a hundred times repaid.

In our Japanese beetle work we do not hope to *eradicate*. We are working to get every person in the state interested in doing what he or she can to delay the spread. It is also hoped that, through education, the people will be familiar with the Japanese beetle and be better able to cope with it as it increases in abundance, thereby reducing the acute conditions, to some extent, which usually occur when the beetle invades a territory. In the meantime the state's forces, combined with those of the federal government, are colonizing parasites and attempting to bring about an equalization of nature's forces. We hope this condition will take place in a comparatively few years, and that the Japanese beetle will be just another insect, handled by general insect control practices.

In closing I wish to emphasize to you the importance of thoroughly acquainting the public, with whom you expect to work, of the different phases of your program, and familiarizing them with the insect in question. This will aid in putting across your program and in obtaining better cooperation and support. —1-6-39.

What Are the Extension Problems in the Classroom Teaching of Entomology?

R. W. LEIBY, *New York State College of Agriculture, Ithaca*

The teacher in entomology at our large institutions should be familiar, at least to some degree, with the insect problems as the extension entomologist must meet them in the field. He is then able to teach more effectively the practical side of entomology. He may even wish to use a concrete example at some point in his course of the way in which threatened losses were averted by common extension practices. It is suggested that consideration be given to the employment in summer of the teacher in economic entomology as a temporary summer extension assistant.

A close working relationship between the teacher in entomology and the extension entomologist is a positive benefit to both. Such a relationship is best maintained when extension entomologists have their offices in the entomology department of an institution rather than in a building which primarily houses extension specialists. Proximity of offices permits more frequent discussion of timely insect problems, quicker identification of specimens, more prompt handling of correspondence and better interchange of ideas. These factors are of mutual benefit to the classroom teacher and the extension entomologist.—1-6-39.

What Are the Extension Problems in the Larger Insect Control Programs?

GEORGE D. JONES, *Columbia, Mo.*

In large scale insect control work, such as in reducing the number of fruits injured by codling moth, preventing crop losses caused by grasshoppers or improving the physical condition of work animals by bot treatment, or the betterment of health conditions or any other county or state-wide insect control project, the planning of the work is one of the most important problems. The control effort must be practical and as inexpensive as possible. Large numbers of people must be reached if the effort is to be successful. A few of the problems will be discussed here rather briefly.

The value of protection and the cost of control measures are among the first items which should be considered in planning insect control work. An individual cannot afford to neglect the proper control of an insect pest if it is practical to prevent it. He is already out the expense of planting, tilling the land, caring for the crops or animals, and other overhead costs. He may not be aware of it, but insect development carries on at the maximum rate when weather conditions favor the pests. Such conditions as a rule do not favor the crops. When this situation occurs, the value of the crop is greater and the importance of protection is greater. I need only to mention that, at the present time, a combination of weather and grasshoppers is threatening agriculture in certain areas in several midwestern and western states. Many farms are already abandoned, and entire communities are left without leaders. The grasshoppers, for several seasons in many areas, have ruined what was left of crops for livestock feed. Further, no orchardist has made a success of orcharding by letting the insects have full sway. The cost of spraying, washing the fruit, using chemical bands and other expenses have increased the cost of producing apples. These costs are fixed costs, and they complicate the situation as well as discourage growers to the point where they are not anxious to cooperate unless a distinct saving can be made.

Insects will never be out of the agricultural picture. Insects of one kind or another have caused complete shifts in agriculture in some sections, and while, so far, we have been able to live with most of the pests, they still reduce our profits and cause us extra effort and expense. Insect control work should be considered permanent, even though the abundance of the pests may vary from year to year. Trying to produce apples without spraying, even though the codling moth infestation may be light, is out of the question. The development and abundance of the pests vary each season, and the growers must have the most accurate information every day in order that they may apply their sprays to best advantage. Codling moth control has been a factor in the apple industry in the United States ever since the industry started. Horticultural society records show that in Missouri, in 1875, it was a pest demanding attention. Considerable headway has been made, but the problem is not solved. The pest is so adapted to conditions that progress is slow. In the eastern states, grasshoppers may not be a problem, but that is no reason why grasshoppers may not destroy crops in western Missouri or Nebraska. The cotton leaf worm or the boll weevil may not be problems in Michigan, but that is no reason why they may not reduce yields for individual farmers at least one-third to one-half in Texas. Looking at insect control work from this angle, it is not too much to say that some insect affects our lives in one way or another all the time.

The question of who should be in charge may be one of the problems in connection with a large scale entomology project. A

first hand knowledge of the habits of the pests is of prime importance, and a person trained in entomological work should be the leader of the project. The question of how to organize for carrying out a program is also very important. In large scale undertakings where an insect has established itself, and is causing widespread losses, the question of coordination with other agencies is very essential. In this period of agricultural planning, the inter-relation of insect control and other agricultural practices should be recognized. Recently this has come to our attention in grasshopper control work. Certain good land use practices are also ideal for grasshopper development. A broad and sympathetic attitude from other agricultural groups is needed and should be encouraged.

Lack of sufficient funds to begin a campaign often presents a problem. Individual farmers may not be financially able to fight the pests. Especially is this true if farm income is low. If several states are involved and the pests have migratory habits, perhaps federal funds may be appropriated. If it is a county or a state-wide problem, local and state organizations must be approached and interested.

State or local organization may not be as difficult as some of the other problems. It will be easy if the leading farmers and interested agencies know that control measures will give results and that such are not too expensive. As long as the control costs bring in good returns, cooperation by individual farmers is easy to get. If control is expensive and if it involves hard or tedious work, interest is likely to subside; individuals may leave the area or give up the fight. At present, many farmers have moved from the grasshopper-infested counties in western states. Those who have stayed are discouraged and are hesitant to enter into a control program. It takes courage to plan programs in the face of such trying conditions.

Surveys based on actual conditions must be made if true conditions are to be known. Patience, a sympathetic attitude and practical information must be in any insect control program. In other words, in any insect control work, it must be recognized that the individual with whom the extension entomologist is working is not to be ignored, but must be a part of the plans. A knowledge of the habits of the pest under consideration, its distribution and its control must be thoroughly understood by all of the men in charge of the work. The amount of time needed for developing the program, and the details of organization, such as the selection of leaders, subject matter, demonstrations and meetings, must be carefully planned in order that interest may be aroused and the work carried out in a successful manner. Result demonstrations are often necessary before large-scale adoption of control practices can be undertaken.

The planning of large-scale insect control projects in extension work can be done and results can be measured. During the past 5 years in Missouri there has been a steady increase in the number of animals treated for bots; 88,000 head were treated during the winter of 1937–38. Every orchardist in the state is following many of the most recent recommendations in an effort to check insect losses. A noticeable increase in the number of farmers in individual counties using grasshopper bait shows evidence of results and adoption of recommended practices. Farmers and county organizations truck chinch bug barrier oil as far as 100 miles. Again this is evidence of a belief in the importance of control efforts. Sheepmen are aroused to the importance of dipping their sheep and it is expected from the interest shown that this practice will become more widely adopted each year. The control of garden pests is receiving more attention than ever before in the state. It should be kept in mind that man has not eradicated a single pest from the earth. In most cases, however, we have been able to find ways of living with them and holding their damage to a minimum. It is hard work and a constant fight, but it is worthy of support from all agencies interested in the welfare of agriculture and farm people.—1-6-39.

What Are the Extension Problems in the Entomology Research Programs?

W. E. BLAUVELT, *Cornell University, Ithaca, N. Y.*

The function of research is to find solutions to problems and that of extension

to bring about the adoption and successful application of the solutions. The two functions are closely integrated, and obviously neither is of the fullest practical value without the other. In practice in the field of economic or agricultural entomology the fields of research and extension overlap and merge to such an extent that it is very difficult to determine where one begins and the other ends. Many official entomologists must fulfill both functions to varying degrees. Pure strains of extension entomologist or research entomologist are probably fewer than the hybrids or dual personalities. Even where the functions of research and extension are assigned to separate individuals the extension entomologist and the research entomologist are mutually interdependent.

The entomological problems are many, varied, often complicated and seldom static. Solutions to these problems are rarely perfect; never permanent. The problems change with changing cultural methods and changing economics, with increasing restrictions on the use of insecticides poisonous to man, with increasing application of chemical research to the syntheses of new insecticides, with increasing consumer standards of quality in agricultural products, and with the waxing or waning of old pests and the appearance of new ones. Control measures must be adapted to varying conditions of locality and season. Many treatments require careful timing based on seasonal insect developments. These factors necessitate the closest possible contact and cooperation between research and extension if the desired results are to be obtained.

The process of evolving a new or improved control method and bringing about its successful application and adoption by growers is a continuous process involving elements of both research and extension all along the line. The research worker cannot ignore the many practical considerations involved in the application of experimental findings to the problem under the varied field conditions, and the extension worker cannot be ignorant of experimental technique if he is properly to evaluate experimental data. The extension worker depends on the research worker for experimental data and detailed information on specific problems from which to formulate recommendations. In turn, through his usually greater opportunity for contact with field conditions throughout the state, the extension worker can be of aid to the investigator. He can keep him informed on local variations in problems, the appearance of new problems and the changing status of old ones. He can by field trials or demonstrations with selected growers test the new methods under varied field conditions to determine the need for further improvement or adaptation before they are recommended for general use.

The extension worker is confronted with a great variety of problems. He is continually besieged with demands for recommendations as to how the grower may best protect his crops from threatened damage or even destruction by insect pests. He cannot evade this responsibility. In order to formulate recommendations that are reasonably sure to give satisfactory results he needs adequate experimental data. On some problems this is available; on others it is not, since there are too many problems and not enough research workers or research funds available. On some problems such as codling moth and rosy aphid there is such an abundance of experimental data that the extension worker must keep in very close touch with the experimental work and workers to evaluate properly the various materials and methods, explain them to growers and aid them in selecting the program best suited to their conditions. He must often discourage the tendency of growers to plunge on new materials still in an experimental stage of development. This, I believe, is what the late Professor C. R. Crosby meant by his familiar dictum, "The function of the extension entomologist is to protect the farmer from the investigator." Progress reports of current research are often made available to growers, and the investigator and extension worker should cooperate in pointing out the experimental nature of many new materials and discouraging their too general use until adequately proved. On many problems there may be no research work in progress and little research data available. This may be only fragmentary and consist of divergent and conflicting reports from workers in other areas where conditions are different. Under these conditions the extension worker may be forced to conduct field trials of an experi-

mental as well as demonstrational nature.

In conclusion, one might say facetiously that extension and research are related as are the two ends of an earthworm. If separated at a certain point either end may survive but only through the regeneration of the lost part and its functions to form a complete earthworm again. —1-6-39.

What Are the Extension Problems With Commercial Entomology?

C. GRAHAM, *University of Maryland, College Park*

With few exceptions, Maryland has no problems with commercial entomologists. There are individuals and organizations in Maryland doing commercial spraying, but, in general, these people come to the Department of Entomology for guidance and cooperate in every way possible. They are filling a much needed position in taking care of insect problems on large estates and around smaller homes. It is our policy to support such commercial organizations and offer them assistance and encouragement.

There are several pest control organizations working in Maryland which specialize in termite control. These oganizations, in general, employ capable men of high standards. Occasional high pressure salesmanship is employed and the public in such cases needs to be protected. The Department of Entomology works in close cooperation with pest control groups, often suggesting competitive bids on jobs that are too big for the owner to handle. The work on a competitive basis is usually completed to the satisfaction of the owner.

It is the duty of the extension entomologist to recommend to the farmer materials that have been tested by experiment stations and proved successful in controlling specific insects in the state. The information is passed to the farmer by personal calls, personal letters, mimeographed sheets, public meetings, newspaper articles and radio. Regardless of what method is used, no attempt is made to influence the grower to use any particular brand, but the basic facts in regard to the constituent materials are presented to him.

Several chemical companies operating in Maryland have in their employment well-trained entomologists who cooperate in every way possible with the extension entomologist. On the other hand, untrained salesmen often try to sell products that have not been thoroughly tested or that have been tested and found inefficient at the recommended strengths.

The latter type commercial salesman is out to sell material handled by the company that has him employed. He is not concerned whether the product meets with the recommendations put out by the experiment station in the state where he is offering the material for sale. The salesman may, however, have data obtained by a research entomologist, employed by his company, to back up his arguments. Often such data are meager and were not obtained under conditions comparable with those for which the product is being recommended. The salesman using his data as a talking point resorts to high powered salesmanship. He paints a glowing picture of the wonderful change the farmer will see in his finished product if he will try *Golden Glow* spray on his apples and peaches. He convinces the farmer that *Golden Glow* is truly the answer to his prayer. The farmer forgets the letter from his extension entomologist. He uses *Golden Glow*, which may not contain the ingredients, either in whole or in part, that are needed for his particular case. When the harvest is over the farmer finds that, instead of fruit with beautiful cheeks kissed by sunbeams, he has fruit with cheeks kissed by insects that would have been controlled if the directions of the extension entomologist had been carried out. The next season the farmer is offered *Golden Glow* that has been taken from and added to until it is now the one perfect spray. In order to make assurance doubly sure, the salesman goes a step further and offers his service in timing the spray applications. This individual attention is attractive to an uninformed grower and often aids in selling him an inferior product. However, these cases are limited and only a few occur each year, the product and the salesman disappearing in the course of about 2 years, only to be supplanted by a new crop of similar salesmen and products.

Aside from high pressure salesmanship of this character, commercial entomology in Maryland seems to be on a sound basis,

and the extension entomologist welcomes the help that it gives in pest control.—1-6-39.

What Are the Extension Problems With the Retail Insecticide Trade?

G. E. LEHKER, *Purdue University, Lafayette, Ind.*

We have found that rural people often experience difficulty in obtaining insecticides recommended by the county agent or extension entomologist. This is especially true of newly developed materials, and in areas where farmers have use for the insecticide in small amounts, as for control of pests in the home vegetable garden. In some cases so much time elapses before materials become readily available that they are no longer recommended, having been replaced by something else. This situation, of course, greatly handicaps us in the work that we are doing.

The problem has been approached in Indiana through the medium of insecticide conferences which enable dealers, county agents and the extension entomologist to sit down together and discuss the situation fully. Two or more counties have usually gone together for a conference at some central location, but if there are enough dealers in one county the meeting can be held on that basis. No attempts have been made to schedule these conferences unless the county agricultural agents concerned are sufficiently interested to attend and bring their dealers with them. Both dealers and county agents, however, have been quick to cooperate inasmuch as both are mutually benefited. Dealers increase sales through handling materials better suited for their intended purpose, and extension workers increase the effectiveness of their work by being able to recommend the best insecticides with full assurance that they are readily obtainable. Of even more importance is the fact that farmers themselves are able to do a cheaper and more efficient job of insect control.

Although the sale of insecticides is usually a minor item with dealers, they are shown the possibility of building a clientele in this field. The necessity of being able to talk insecticides and insect control intelligently is stressed, as it helps to build confidence among customers. Dealers also have a responsibility in knowing that materials they sell are properly applied for best results; otherwise the buyers may not come back a second time. Dealers who do not handle appliances should at least point out their importance to customers not properly equipped and mention where this equipment is obtainable. The same is true of carriers of arsenate of lead and other materials which need to be mixed before being used. In this latter case the seller should also be able to give the proper dilutions and mention the insects against which the material is especially effective. Many dealers refer to experiment station or government publications for this information.

Many of the insecticides sold by dealers are proprietary compounds which have an important place in the field of insect control. We suggest that they stock only those products that have an analysis of the active ingredients marked on the label. With the aid of this information dealers can judge the value of the compounds and recommend them with assurance. It also enables them to avoid stocking large quantities of ineffective insecticides which must later be passed on to the public in order to avoid the losses that would otherwise occur.

Until we have a better method of maintaining contact with dealers in insecticides, we feel that conferences of this kind are well worth while as a means of solving many of the problems in this field.—1-6-39.

What Are the Extension Entomologists' Problems With Other Extension Agencies?

J. O. ROWELL, *North Carolina State College Station, Raleigh,* and J. M. AMOS, *University of Delaware, Newark*

1. Insect control recommendations which may be disseminated by other extension agencies such as the extension horticulturist, extension tobacco specialist or extension poultry specialist, should originate in the office of the extension entomologist. By this statement it is implied that no extension agency should make insect control recommendations

which have not been approved by the extension entomologist. In like manner, the extension entomologist should coordinate his insect control recommendations with those of the research entomologist of the state agricultural colleges and experiment stations and of the U. S. Department of Agriculture.

2. Vocational agricultural teachers, agents of the Farm Security Administration, veterinarians and in many cases medical doctors are called upon to make insect control recommendations. These agencies should be reached in some manner and supplied with the most recent information on insect control problems. It is certain that the problems of insect control are unlimited. Therefore, no division, department or individual states could solve this problem without the harmonious cooperation of all agencies involved in agricultural pursuits.

3. Since much insect control information is disseminated by insecticide manufacturers and dealers, commercial insect exterminating companies and similar agencies, it is the responsibility of the extension entomologist to get into the hands of such agencies the latest and most accurate information concerning insect problems. Some difficulty has been experienced when working with retail insecticide dealers in attempting to have them read the label and know what poison they are selling for different insects. They prefer to sell merely by trade names and often have three to five concoctions with the same ingredients. One dealer had 9 or 10 different trade named lice powders for poultry and all contained sodium fluoride. It will take a long period of effort in the education of insecticide dealers if they are to know what they are selling to the public.—1-6-39.

The Logical Extension Approach in the Meeting of Insect Problems

H. W. HOCHBAUM, *Extension Service, U. S. Department of Agriculture*

After I had told Mr. Jones I would be glad to take part in this conference, I became a little frightened when I read the imposing title for the assignment he gave me later—The Logical Extension Approach in Meeting Insect Problems.

Then I sought refuge and light in Webster, but did not find much, for the big book tells us that logic is "The science of generalization, judgment, classification, reasoning and systematic arrangement." That didn't seem to help a lot. Worse than ever, below this formidable array of words, I found, "Logicians have never agreed upon the definition of logic. Even in medieval times there was doubt as to whether it is a mode of knowing, or an instrument of knowledge, or science, or an art." Still further down the page, I read that logic means "in accordance with the inferences reasonably drawn from preceding or surrounding events or circumstances; reasonable to be expected under the circumstances."

Now in extension work, we find little that is "reasonable to be expected under all circumstances." So without further defining and without wishing to seem unreasonable, let me use a speaker's privilege and make my own interpretation. I am going to speak on the educational approach in meeting insect problems.

In extension work we are concerned with two major groups of effort: (1) to give information, (2) to teach—education. There is quite a distinction. The first we shall always have to do. It is a service. By means of letters, news articles, meetings, demonstrations, we tell and we show how to meet individual and group problems, what to do for this insect or that. There may be learning in this process. But I am skeptical that the mere dissemination of information means much to the great majority of people in the way of educating them, getting them to learn. To be sure, in emergencies when pests are doing a lot of damage we do help thousands. But with some of the old enemies always with us, it doesn't seem as easy to get people to change.

And there is no learning without change. Giving information is not teaching, nor merely absorbing information, learning. To learn, an individual must act, do something, change practices, have new experiences, develop new attitudes, appreciations, and acquire judgments based on all these to help him meet his problems. And these changes, these actions, these struggles to acquire new experiences, attitudes, judgments, must bring satisfactions, successes, or there is no

learning. Of course, all this is more difficult to plan, to carry on, than merely giving information. For first of all we have to study the man, what his situations, practices and problems are, how he reacts and how he may learn.

The start is the want or wants of the individual, not what you think he should know. Unless he feels a difficulty, a dissatisfaction and need, a want, we cannot get far with teaching him. Let us never forget that the thing we may be recommending may not be the end for the farmer, although it may seem so to us. For him it is largely a means to an end, a way of satisfying some wants he has. Human beings are driven by thousands of wants.

Say you are writing a circular letter. Farmer Jones should come first, not you and your wants. An effective letter appeals directly to Farmer Jones in the very first line. The agent foregoes telling what he or the specialist thinks or about the life history of this or that bug. He plunges right into the matter of getting Farmer Jones' attention and interest, his recognition of wants that are based on actual needs. The first paragraph of interest-compelling letters would discuss Farmer Jones' problems in terms of the following: "You, Farmer Jones, have this problem. You are looking for an answer. You have these wants. You want these satisfactions. You will find this to be a solution to your problem. It may bring you a new car, new equipment, money to pay taxes and interest or to buy convenient comforts for your wife and children."

At this stage, Farmer Jones should be given little technical information on subject matter. There will be opportunity to give him all the subject matter he needs after he acts. Let him first realize his problems, his wants and the need for a solution. Let the agent picture only the basic needs and the impelling urge. Farmer Jones will not read much beyond the first paragraph unless it is a "you" appeal, unless it brings him up with a start to a realization that he has the wants and that he wishes to satisfy them. Then the farmer is likely to read on, to listen more carefully, to chase the thing down further to find out what it is all about. At least, he will go far enough to find out what the answer is, and consider whether it fits his situation and wants.

So this answer, this solution to wants logically follows. To the farmer's query "What of it?" the well-planned letter, the well-planned talk, the well-thought-out plan of work now offers a solution which must appeal to him as the right solution. No emphasis is placed on the technical. A well-written "solution" paragraph presents the solution, the recommended practices, as a simple, practical and easily attainable answer to the reader's problems and wants.

Now Farmer Jones may say "Well, that reads pretty good; that seems reasonable." Then he may be led to do something about it. Perhaps he can be moved to take the first step in changing his practices by sending for more information, for circulars. Perhaps he may go out, though tired from the day's labors and the late chores, plow through mud, rain or snow, to attend a meeting. It is more likely now that he will be keyed to stop and look at demonstrations, posters, exhibits or other things used to hold the idea of better practices before people. Perhaps he may be interested or follow his children's interest in a slogan, essay, poster or reasons contest carried on in connection with the project. He will also pay more attention to survey cards which may be sent him, or read the news articles, the stories that appear in the local paper or farm journals. Maybe he will go on that tour. Perhaps he will talk to his neighbors about the problem, the solution. He may even say now, "I believe there is something in that for us. I'm going to see the county agent."

Somewhere in the plan the extension worker is sure to provide a means to spur the farmer to act, to do one of the things mentioned above. Perhaps a self-addressed card is inclosed in some of the circular letters with the injunction, "If you will sign and return the inclosed card you will be sent further information on fighting the bean weevil, grasshopper or whatever it is."

Quite successful too has been the following, "If you intend to do so-and-so this year, please sign your name below and return it to me. Other available information will be mailed to you."

What satisfactions will Farmer Jones get? Of course, he may hesitate to follow the promptings to act. But many more Farmer Joneses will be influenced to act, if the letter, the news articles, the poster, the circular, meetings, demonstrations,

picture the satisfactions which could be won if the recommended solution is adopted. Citations of the number of farmers who have adopted the practices and the results they have won give the reader or the listener confidence and influence him to act.

Every means must be used to stamp the recommended solution on the mind. It is really not to be wondered at that so few people adopt our recommendations when so little is done and so few agencies are used. One news article, one meeting, one circular letter is not going to affect many people. Moreover, many of these present the material in such a technical form that it is hard to understand what we are talking about. Let us put into practice the things we are recommending in such form that he who runs may read, that the farmer can do the things without calling up the county agent and finding out what we really mean.

These terse statements of recommended practices serve a fundamental purpose. They represent subject matter boiled down to the essential steps that the reader should take as the solution to his problem. They are positive, practical directions of what to do. They represent a translation of technical terms and general principles into language that all will understand. They are the hurdles over which the farmer has to climb to reach the promised satisfactions. The more simply they are stated and the oftener they appear before him, the more likely he will recognize them as solutions for his problems.

Tell them quickly and tell them often. Habits are hard to change. Moreover, if the farmer is to change his practices he must make readjustments in his farming operations, do things which he has not done before. He must have time to think things over, to weigh the significance of these changes in terms of his farming and his pocketbook. He must consider how and when to buy the various things that are called for by the recommended practices. Therefore, his resolutions to change, to adopt new practices, must be kept alive. He ought to receive occasional reminders to help him think everything through, to feel sure that he has the problem, that he wants the solution and will learn to apply it successfully.

After Farmer Jones has made his decision, and has acted to accept the recommended changes in practices, then he needs to be given all possible help and information that his success may be sure. Now is the time to send him seasonal, timely hints and reminders, detailed instructions and helps. He is more likely to want the bulletins or circulars and read them now. He will read news articles that cover details of method and will take part in meetings, tours and visits to demonstrations. Now is the time to give him more instruction in trying the recommended practices, the solutions. This may involve sending him frequent circular letters. In a "better apple" campaign, spray cards go out to the fruit grower soliciting him to look for certain crucial stages in the cycles of insects and diseases, and instructing him how to make and apply control sprays. Likewise some agents who are recommending the growing of alfalfa send farmers who need to grow alfalfa timely hints on how to select fields, take soil samples, test for lime requirement, prepare land, and on seeding and summer care. The farmer has responded. Now he needs to be taught success. Then satisfaction will be his and some true learning won.

This is the formula that I should like to teach you. This is the formula that has its basis in the soundest principles of learning and education. This is the formula with which we have been exceptionally successful in planning extension work in a great variety of projects. This is the formula that will help you bring about a continuity of teaching effort and insure that the farmer you are trying to reach will do more than merely absorb information. This is the formula that will get him to think, react, act, adopt your practices, be successful, acquire new attitudes, new judgments and new abilities to solve other problems. This is the formula that you can use in every meeting, every news article, every demonstration, every circular letter, every means that you use: *want*, *solution*, *action*, *satisfaction*. Begin with the farmer's wants. Have the solution that is practical and understandable and in terms of his real needs—a means to the end he seeks. Lead him to act, to do something about it, to change. And then see that he makes these changes successfully by giving him the helps that will carry him through. Remember constantly there is no learning without change. There is no learning unless that

change brings satisfaction. Satisfactions can come only if the solution is an answer to a real problem, to a real want.

How may we find the farmer's needs? Two major steps are involved. The first of these is to work with local leaders, county agents, and other specialists and study together real situations. The problem is deeper than this insect and that remedy. Why does the farmer not do the things we think he ought to do? What do horticulturist, farm-management specialist, agronomist, marketing specialist, know of the situation and trends? How does the problem affect his income? Why does he spray indifferently, in our opinion, give only four sprays when we say 12 or 13? What are the land-use situations that surround him? How do idle lands, insect harbors, affect the fight he should make? How do the great soil conservation and AAA programs and practices affect his farming practices? What kind of living is he making? Is he farming land that would better be in forest? How difficult are the practices we recommend? How practical for him under his conditions? Can he jump all the hurdles we place before him? Just what are his practices and why?

So together, agents, leaders, specialists, work out as nearly as they can situation, hypothesis, solution and teaching method. Thus will come the much-needed coordination in extension work, *viz.*, by studying, analyzing, working together, instead of each worker making his independent and too specialized approach.

Now comes the second step. County agent and local leaders interview, say, 50 to 100 farmers known to have the problem. They find out just what individual situations are, what the condition is, what the farmer's practices are and why he does things his way. Sometimes ignorance of better methods is the reason. More often there is good reason for the farmer's way of doing, a problem which he has not been able to meet.

Now as a result of this study, and survey, agents and specialists go over their recommendations and adjust them to meet actual situations. They may find new problems for which their program was no answer. In other words, they are making a real diagnosis and will prepare a remedy or practice to meet the need.

I have yet to go through this procedure of studying local practices and needs in the county and find that the practices first suggested do not have to be changed in some degree. Moreover, this procedure of bringing out real situations, by getting farmers to study and survey, results in far more farmers recognizing a problem, feeling a want—and that, as I told you, is the first step in learning, the first thing toward getting men to change. And, over and over again, there is no learning unless there is a change, no learning unless that change is satisfying.—1-6-39.

Eradication of the Citrus Blackfly in Key West, Fla.

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Spiny citrus whitefly, or citrus blackfly, *Aleurocanthus woglumi* Ashby, was first brought to the attention of the State Plant Board of Florida in May, 1916, when Quarantine Inspector J. H. Montgomery made a trip to Nassau for the purpose of investigating a rumor that citrus canker occurred in some of the Bahama Islands. Dr. Montgomery's investigations did not reveal the presence of canker, but they did bring to light the existence there of a then little-known insect pest, namely, citrus blackfly. Many citrus trees on the island of New Providence had died from its attacks, and others had been cut down by their owners after ineffective efforts to control the pest. Subsequent to Dr. Montgomery's visit the colonial legislature passed a plant protection act, and a systematic attempt was made to control citrus blackfly. These efforts were ineffective, at least on the Island of New Providence.

As a result of inquiries made by the Board, John R. Johnston, Chief, Commission Sanidad Vegetal, Havana, Cuba, in a letter dated May 31, 1916, stated that citrus blackfly had been found near Guantanamo in August, 1915. In December, 1916, it was reported from the vicinity of Havana, where it was causing considerable damage to citrus and mango trees.

The senior author visited Cuba in October, 1917, for the purpose of securing

more information concerning citrus blackfly, urging greater activity in Cuba toward subduing the pest and arranging for such cooperation with the Cuban government as would tend to reduce the chances of the pest being introduced into Florida. In November, 1917, the Cuban congress appropriated the sum of $50,000 for citrus blackfly control. At the request of the Cuban authorities, the Plant Board loaned the services of three of its best inspectors, Frank Stirling, L. R. Warner and H. D. Bollinger, to assist in organizing and supervising control activities. From November, 1917, to April, 1918, a more or less vigorous spray campaign was waged against the pest in the vicinity of Havana, and the insect population materially reduced. No efforts of consequence were made to control blackfly at Guantanamo. The spraying activities near Havana were discontinued, and the insect soon became as abundant as before.

In August, 1917, citrus blackfly was found by Harold Morrison, of the federal horticultural board, at both ends of the Panama Canal. It has been reported from Jamaica and other West Indian islands, as well as from Costa Rica and other Central American countries.

Repeated interceptions at Florida ports of live, immature stages of citrus blackfly on boutonnieres worn by passengers, on plants and in shipments of plant products from Cuba and Nassau convinced the Plant Board that introduction into Florida was inevitable. It was felt, however, that the degree of risk might be reduced somewhat by reduction in the severity of the infestation in the two islands, and that this could best be brought about through the introduction and establishment of natural enemies of citrus blackfly. The Board was successful in its efforts to interest officials of the U. S. Department of Agriculture and of the Cuban government in financing an expedition to Malaya to collect parasites and predators of the pest.

NATURAL ENEMIES.—The story of the expedition resulting in the successful introduction and establishing of natural enemies of blackfly in Cuba is well told in Technical Bulletin No. 320, U. S. Department of Agriculture, by Clausen & Berry (1932).

It was found that in the Far East citrus blackfly is of no economic importance due almost exclusively to mortality effected by natural enemies. Of the parasites found in the Orient, *Eretmocerus serius* Silvestri has been established in Cuba where it is very effective. Among the Coccinellid predators, a species of *Cryptognatha* and *Scymnus smithianus* Silvestri are now established in that country. These latter are apparently not as effective as *Eretmocerus*. The initial introduction of the parasite into the Bahama Islands for some reason did not result in establishment, and a second introduction has been made. At this point, and somewhat parenthetically, attention is directed to the uncertainty of biological control of which the Bahama situation is a striking example. By this we do not mean to minimize the advantages of control by means of parasites and predators, but rather to emphasize the necessity of having well-developed and effective mechanical measures available.

SPRAY ACTIVITIES.—Forewarned is forearmed, and when an infestation of citrus blackfly was found on the Island of Key West, August 10, 1934, by Plant Board Inspector J. H. Sealey, eradication measures were immediately instituted. It was known that in Panama the life cycle of the citrus blackfly varies from 45 to 113 days, and plans were made at Key West for the application of an oil spray at intervals of 20 days.

Specialists of the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, recommended the use of an oil with an unsulfonatable residue of not less than 85 (preferably 90 or over) and a viscosity of between 60 and 100 degrees Saybolt (preferably in the 60's but not exceeding 100 degrees). An oil of this grade was not readily available at that time, and the Bureau approved the use of a Standard Oil Company *Diamond Paraffin Oil* with an unsulfonation of 76 and a viscosity of 105 degrees. The emulsion was made of 2 gallons of fish oil soap, 2 gallons of oil and 1 gallon of water. The oil content of the spray mixture as used varied with the season and ranged from two thirds per cent to 1 per cent. It is interesting to note that even though this oil spray was applied to citrus trees every 20 days from September, 1934, to June, 1937, except for about 2 months during the spring of 1936, no apparent damage was caused to the trees by the repeated applications.

At first the spray was applied to all

plants—23 in number—known to be hosts of the citrus blackfly in Key West. Citrus and mango appeared to be the primary hosts, and as eradication work progressed and the insect population decreased the oil was applied to these two hosts only. Amounts of the mixture used varied with the size of the tree, but sufficient material was applied to drench all parts of the tree. Applications were made by the use of power sprayers, of which there were available at Key West four large federal sprayers loaned by the Bureau, and four *Bean* outfits purchased by the Plant Board. Pressure was maintained at about 400 pounds.

Difficulties encountered in the application of eradication measures were many and varied. There were no commercial plantings jeopardized at Key West and as a rule the citizens were indifferent as to the outcome of the project. Unsupported by the weight of public opinion, without which any eradication project is severely handicapped, the Board was forced to appeal to the courts, both civil and criminal, many times. It was not until May, 1936, when a favorable ruling of the State Supreme Court convinced objectors that continued opposition would be of no avail, that real progress in eradication was made.

Other difficulties encountered at Key West were unique. Rainwater stored in cisterns during the rainy season is the only source of fresh water on the island. As our forces used several thousand gallons daily, the problem of securing fresh water during the dry season, from the last of October to the middle of May, was a serious one. It was met chiefly through the ability of the inspector in charge, H. S. McClanahan, to persuade citizens to have spare cisterns pumped out and cleaned at no cost. Water thus secured was stored in our own cisterns.

The infested area was wholly within the limits of the city of Key West. The majority of the properties are small ones, and practically all of them are fenced, the gates of which are frequently locked. In some cases entry into the walled yards was possible only through the house itself, which meant that the spray crews had to drag many feet of hose through the front door and out a side door or window into the yard. When the spray crews reached the yard, they frequently found all available space filled with the family laundry. In fact, many a return trip was necessary in order to spray a property on which the laundry was hanging when the crews first called.

Many trees grew close to the houses and, in order to keep the spray from drifting into open windows and doors, it was frequently necessary to hang tarpaulins between the tree and the house. Tarpaulins were part of the equipment of each outfit and were used to cover fish ponds, cisterns, and guttering and troughs leading from the house to the cistern.

RESULTS.—Between February 26, 1937, when the last live immature stages of citrus blackfly were found, and June 30, 1937, primary hosts received six applications of spray. During the same period four complete, intensive inspections were made with negative results. With this information at hand the Board, on June 30, 1937, ordered discontinuance of all eradication activities, with the exception of quarantine enforcement.

In the fall of 1937, and again in the spring of 1938, intensive inspections were made of host plants in Key West. When no indications of citrus blackfly were found on either survey, Chairman R. P. Terry of the State Plant Board felt justified in concluding that eradication was an accomplished fact, and on April 13, 1938, authorized discontinuance of quarantine enforcement. That this conclusion was warranted is evidenced by the fact that another intensive inspection of the infested area was made last fall with negative results.

The total cost of the project was $197,464.95. Federal contributions, through the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, were $36,000, while state funds expended amounted to $161,464.95. With proper cooperation on the part of property occupants at Key West this project should have been completed in 1 year and at a considerable reduction of the total amount expended.—4-1-39.

LITERATURE CITED

Clausen, Curtis P., and Paul A. Berry. 1932. The citrus blackfly in Asia, and the importation of its natural enemies into tropical America. U. S. Dept. Ag. Tech. Bul. 320. 58 pp.

Further Studies With Ethylene Dichloride Emulsion for the Control of the Peach Borer

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At the last annual meeting of the Cotton States Branch the writer (1938) reported that ethylene dichloride emulsion maintained its effectiveness against the peach borer, *Conopia exitiosa* (Say), late in the fall in New York and during warm periods in the winter in Georgia, when soil temperatures were too low for the effective use of paradichlorobenzene. To broaden our knowledge concerning the relative effectiveness of ethylene dichloride emulsion and paradichlorobenzene crystals, tests were conducted near Carbondale and Vienna, Ill.,* early in the spring and near Fort Valley, Ga., 2 weeks before the usual fall applications of paradichlorobenzene.

EXPERIMENTAL PROCEDURE.—The ethylene dichloride emulsion was prepared by stirring 9 parts by volume of ethylene dichloride into 1 part by volume of a potash fish-oil soap containing approximately 30 per cent of soap. This mixture was then diluted with water to the required strength and poured around the base of the tree, so that the soil immediately surrounding the tree and the lower part of the trunk received some of the material. The emulsions used in these experiments were applied without previous preparation of the soil. In no case was the level of the soil raised before treatment. Some soil, however, was placed around the base of the tree after treatment. The paradichlorobenzene crystals were applied by standard methods.

RESULTS.—The results of these experiments are given in table 1.

INJURY TO TREES.—Ethylene dichloride emulsion caused no tree injury in Illinois. In Georgia there was considerable cracking of the soil around the 5- and 7-year-old trees, and, as the soil was not prepared before treatment, the cracks admitted the ethylene dichloride and in some cases allowed it to settle close to the tree trunk below ground, a condition conducive to tree injury. Furthermore, the soil temperature was unusually high during the period of the experiments and the danger of injury by this chemical is greater when used during hot weather. Owing to these conditions, several of the 5- and 7-year-old trees showed slight injury from the stronger but none from the weaker emulsions. There was considerable injury to June-budded nursery stock from the 7.5 and 10 per cent emulsions, but none from the 5 per cent strength. No tree injury resulted when ethylene dichloride emulsion was used around trees of other ages.

In Georgia, paradichlorobenzene crystals caused considerable injury. Trees as old as 7 years were injured into the cambium. Sixty per cent of the trees of that age treated with 1 ounce per tree showed cambium injury. Fifty per cent of the 5-year-old trees treated with three-quarter ounce per tree showed cambium injury, some of which was severe. Some 4-year-old trees were injured by treatment with three-quarters of an ounce per tree, some 3-year-old trees by one-half ounce, and some 2-year-old trees by one-quarter of an ounce. A treatment of one-eighth ounce per tree killed some of the 1-year-old orchard trees and June-budded nursery stock. In Illinois the one-quarter ounce dose caused cambium injury to 2-year-old orchard trees, at a time when soil temperatures were too low to cause a gas concentration sufficient to kill the borers. The trees thus injured seemed to suffer no permanent ill effect, however.

DISCUSSION OF RESULTS.—Ethylene dichloride emulsion when applied early in the spring in Illinois, when soil temperatures were too low for paradichlorobenzene to be effective, gave excellent borer control. The results were about as good as those obtained previously from early fall experiments. This material when applied early in the fall in Georgia proved to be an excellent control measure, the results confirming the results of other years. Ethylene dichloride gave 100 per cent control in most cases in Georgia without previous preparation of the soil. As a precaution against tree injury, however, any cracks in the soil around the

* In cooperation with W. P. Flint of the Illinois Natural History Survey and the Illinois Agricultural Experiment Station, and S. C. Chandler of the Illinois Natural History Survey.

Table 1.—Comparative effectiveness of ethylene dichloride emulsion and paradichlorobenzene crystals for peach borer control, Carbondale and Vienna, Ill., March 16–19, and Fort Valley, Ga., October 6–8, 1938,

Insecticide	Quantity Per Tree	Illinois			Georgia		
		Number of Trees	Total Number of Borers	Percentage of Borers Dead	Number of Trees	Total Number of Borers	Percentage of Borers Dead
Ten-Year-Old Trees in Illinois and 7-Year-Old Trees in Georgia							
Ethylene dichloride							
25 per cent	½ pint	20	134	97.0	20	86	100.0
20 per cent	½ pint	20	186	92.5	20	101	100.0
Paradichlorobenzene	1 ounce	10	35	34.3	10	19	94.7
Check (no treatment)	—	5	58	0.0	5	49	0.0
Five-Year-Old Trees							
Ethylene dichloride							
20 per cent	½ pint	—	—	—	20	63	100.0
15 per cent	½ pint	—	—	—	20	95	99.0*
Paradichlorobenzene	¾ ounce	—	—	—	10	15	100.0
Check (no treatment)	—	—	—	—	5	40	0.0
Four-Year-Old Trees							
Ethylene dichloride							
20 per cent	½ pint	10	85	97.6	20	68	100.0
15 per cent	½ pint	10	53	96.2	20	29	93.1
Paradichlorobenzene	¾ ounce	10	116	12.9	10	4	100.0
Check (no treatment)	—	5	82	0.0	5	19	0.0
Three-Year-Old Trees							
Ethylene dichloride							
15 per cent	½ pint	—	—	—	20	32	100.0
12.5 per cent	½ pint	—	—	—	10	11	100.0
10 per cent	½ pint	—	—	—	10	15	100.0
Paradichlorobenzene	½ ounce	—	—	—	10	4	100.0
Check (no treatment)	—	—	—	—	5	12	0.0
Two-Year-Old Trees							
Ethylene dichloride							
15 per cent	¼ pint	20	52	92.3†	19	17	100.0
12.5 per cent	¼ pint	20	51	94.1	20	23	100.0
Paradichlorobenzene	¼ ounce	10	54	16.7	10	7	100.0
Check (no treatment)	—	5	10	0.0	5	11	9.1
One-Year-Old Trees							
Ethylene dichloride							
10 per cent	⅛ pint	—	—	—	20	9‡	100.0‡
7.5 percent	⅛ pint	—	—	—	20	6‡	100.0‡
Paradichlorobenzene	⅛ ounce	—	—	—	10	5§	0.0
Check (no treatment)	—	—	—	—	5	4	0.0
Nursery Stock, June buds							
Ethylene dichloride							
10 per cent	⅛ pint	—	—	—	20	51	96.1
7.5 per cent	⅛ pint	—	—	—	10	10	100.0
5 per cent	⅛ pint	—	—	—	10	23	95.7**
Paradichlorobenzene	⅛ ounce	—	—	—	10	3	0.0
Check (no treatment)	—	—	—	—	5	8	0.0

* The remaining 1 per cent stupefied. Probably would die.
† One of the four live borers in a hibernaculum.
‡ Does not include borers on bottom of root stock with channel packed with particles of wood.
§ Mostly in root stock.
** The remaining 4.3 per cent in a hibernaculum on bottom of root stock.

trees should be filled with soil before the emulsion is applied, and the material should not be used during hot weather.

The results of these experiments would justify no change in the doses of ethylene dichloride emulsion suggested at the last annual meeting of the Cotton States Branch (1938) as sufficient to give effective borer control with minimum danger of tree injury, except perhaps the use of a 20 per cent instead of a 25 per cent emulsion for trees 6 years old or older in the South. The indications are that nursery stock on 1- or 2-year-old roots may be safely and effectively treated, before it is dug, with one-eighth pint per tree of the 7.5 per cent strength, and June-budded stock given a similar treatment with

one-eighth pint of the 5 per cent strength. It is believed better, however, to treat all nursery stock after it is dug by spraying the soil packed and settled around bundles of the stock heeled in an upright position with a 2.5 or 3 per cent emulsion at the rate of 1 quart to each 15 trees. That treatment should be made during the dormant season before any growth begins in the spring, and the soil should be dry when the material is applied.

In these experiments, paradichlorobenzene crystals failed to control the peach borer in Illinois, owing to an insufficient accumulation of gas from the chemical used around the trees at that time. The conditions during the period of the experiments in Georgia were excellent for building up a high concentration of gas from the paradichlorobenzene crystals, and as a result very good borer control was obtained, but with more than the usual amount of tree injury. The results of these experiments show conclusively that paradichlorobenzene crystals should not be used on young peach trees in the southeastern states because of the danger of serious tree injury, and that ethylene dichloride emulsion is safer than paradichlorobenzene for use on the older trees in that area.

It will be noted from table 1 that, in the 5-year-old trees, on an average 8 borers per tree were found in untreated trees and only 1.5 in trees treated with paradichlorobenzene. This fact indicates that some of the small dead borers in the treated trees had decomposed or disintegrated beyond recognition or were devoured by maggots before the counts were made. As some of the small dead borers were most likely missed and all live ones found when the trees were examined, the percentage of borers dead as given in table 1 is in all probability somewhat lower than was actually the case.

A SIMPLIFIED METHOD FOR EMULSIFYING ETHYLENE DICHLORIDE.—A simple method for preparing ethylene dichloride emulsion has been developed at the Fort Valley laboratory. In making a 50 per cent emulsion 8 volumes of water are added to 1 volume of potash fish-oil soap, containing approximately 30 per cent of soap, after which 9 volumes of ethylene dichloride are added and the constituents emulsified cold by pumping. This procedure not only simplifies the method of emulsification but reduces the danger of a reversed or broken-down emulsion when this material is prepared by the orchardist. A 50 per cent stock emulsion of ethylene dichloride prepared by this method on October 10, 1938, was holding up well on February 18, 1939.

SUMMARY.—Ethylene dichloride emulsion maintained its effectiveness against the peach borer, *Conopia exitiosa* (Say), early in the spring in Illinois, when soil temperatures were too low for the effective use of paradichlorobenzene. Although the soil was not prepared before treatment, ethylene dichloride emulsion gave 100 per cent control of the peach borer in most of the early fall experiments in Georgia. As a precaution against tree injury, any cracks in the soil around the trees should be filled with soil before the ethylene dichloride is applied, and the material should not be used during hot weather. The results of the experiments reported in this paper show conclusively that paradichlorobenzene crystals should not be used on young peach trees in the southeastern states because of the danger of serious tree injury, and that ethylene dichloride emulsion is safer than paradichlorobenzene for use even on the older trees in that area. In making a 50 per cent emulsion of ethylene dichloride by a new and simplified method, 8 volumes of water are added to 1 volume of potash fish-oil soap, containing approximately 30 per cent of soap, after which 9 volumes of ethylene dichloride are added and the constituents emulsified cold by pumping. —4-1-39.

LITERATURE CITED

Snapp, Oliver I. 1938. Recent experiments with ethylene dichloride emulsion for peach borer control. JOUR. ECON. ENT. 31(6):725–7. Dec.

THE sweetpotato weevil quarantine proclamation of the state of California, as revised effective July 10, 1939, added to the regulated area Conecuh and Baldwin Counties, Ala., Marion, Stone and Walthall Counties, Miss., and Thomas County, Ga., and eliminated Decatur County, Ga., from that area.

Increases in Citrus Scale Insect Infestations From Heavy Residue and From Copper Spray Mixtures

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Growers of citrus fruits have known for many years that troublesome infestations of scale insects almost always follow the use of Bordeaux spray for control of melanose and scab. Fawcett (1911), working experimentally with this mixture, explained heavy fruit drop from trees sprayed with Bordeaux mixture as due to the increases of scale insects which the use of this mixture caused. Winston & Yothers (1921) advised combining oil emulsions with Bordeaux mixture to reduce this build-up of scale insects, but warned that a midsummer oil emulsion spray would also be necessary to control scales after either Bordeaux mixture or Bordeaux-oil emulsion. Winston, Bowman & Yothers (1923) published data on repression of the entomogenous fungi by copper sprays, and definitely attributed build-up of scale insect and whitefly populations after spraying with Bordeaux mixture to destruction of the beneficial fungi. Recently Thompson (1938) has reported that increases of the purple scale, *Lepidosaphes beckii* (Newm.), were least after single applications of proprietary copper-compound sprays, greater after 3:3:100 Bordeaux spray and still greater after Bordeaux 6:6:100. Two applications of these materials gave greater increases than did single sprayings. Because of the difficulties in controlling scale insects after spraying with Bordeaux mixture, citrus growers have become reluctant to spray with copper materials, and have suffered losses in fruit quality from lack of control of the plant diseases when copper sprays were needed but were omitted.

Some information on the factors which tend to increase scale insect populations has been obtained in experiments in rust mite control. Since 1925 the Orlando, Fla., laboratory has been investigating the possibility of prolonging effectiveness of sulfur combinations in sprays by adding adhesives. Several of the adhesives left heavy residues on the leaves and fruits but did not destroy the entomogenous fungi. Nevertheless, scale insect increases similar to those from Bordeaux mixture were encountered and were reported by Osburn & Spencer (1938). This led to a theory that possibly the persistent residue left on leaves after spraying with Bordeaux mixture was an important factor, and that reduction of the entomogenous fungi by copper was not the only explanation for scale insect build-up.

In 1936 plans were made for an experiment to throw light on the relative importance of heavy noninsecticidal residues and of copper in scale insect increases of this kind. One plot was to receive Bordeaux mixture, another the hydrated lime without copper sulfate, a third the same amount of copper sulfate without the hydrated line and a fourth plot was to be unsprayed. However, as a preliminary trial of the copper sulfate spray on three trees demonstrated conclusively, by the resulting defoliation, that the mixture was unsafe, low-residue substitutes for Bordeaux mixture had to be used in plot 3. The work was repeated with slight modifications in 1937 on other trees, and again in 1938, with quite consistent results. Since the 1938 experiment was set up on more nearly uniform trees and was planned so that statistical tests might be applied better, it will be discussed in detail.

EXPERIMENTAL PROCEDURE.—A small grove of Parson Brown orange trees was blocked out in groups of three trees. Each treatment was applied to five well-scattered groups, or to 15 trees in all. The treatments were as follows:

Plot 1. Bordeaux mixture (copper *and* heavy residue):
- Copper sulfate ("snow").....6 pounds
- Hydrated lime.....6 pounds
- Water.....100 gallons

Plot 2. Heavy-residue, no-copper spray:
- Hydrated lime.....6 pounds
- Aluminum sulfate.....6 pounds
- Water.....100 gallons

Plot 3. Ammoniacal copper carbonate (copper with low residue):
- Cupric carbonate (50 per cent Cu).....1 pound

* The author desires to acknowledge the helpful suggestions of B. A. Porter and F. M. Wadley regarding the presentation of data in this paper.

Ammonium hydroxide, C.P. 9 pints
Water.....100 gallons
Plot 4. Unsprayed.

Two applications of these sprays were made, the first on April 20 and the second on July 8, each time with thorough coverage of both upper and lower leaf surfaces and of fruits and wood. In plots 1 and 3 the entomogenous fungi were almost completely eliminated until late in the year when the copper deposits had weathered away. During the last week of October of 50 fruits and the grand total for the five samples obtained. Needless to say, this method of computing from a minimum figure for each class is extremely conservative.

RESULTS.—The tree and plot records were treated statistically by the method of analysis of variance. With the purple scale, heavy build-up above the unsprayed plot level was encountered in the Bordeaux mixture plot and in the hydrated lime plot; these increases were highly insignificant statistically. There

Table 1.—Infestations of the purple scale and the Florida red scale from copper and residue sprays.

PLOT	SPRAY TREATMENT	PURPLE SCALE		FLORIDA RED SCALE	
		Fruits Infested, Per Cent*	Scale Population, Number	Fruits Infested, Per Cent*	Scale Population, Number
1	Bordeaux 6:6:100 (Copper and heavy residue)	98.8†	10,747†	70.8†	2,467†
2	Hydrated lime+aluminum sulfate (heavy residue, no copper)	96.4†	5,821†	24.8†	422
3	Ammoniacal copper carbonate (low-residue and copper)	67.6	1,219	14.4	396
4	None	58.8	537	3.2	8

* Average of the percentages derived from each of 5 samples of 50 fruits each.
† Difference from unsprayed trees highly significant.

picking of fruit in these plots was begun, and 50 oranges from one of each three trees were examined for infestation by the purple scale and by the Florida red scale, *Chrysomphalus aonidum* (L.). Separate records were kept for the two species. Since there were five groups of trees in each treatment the plot records are based on 250 fruits each. The fruits were tallied in the following four classes by a method recently proposed by Spencer & Osburn (1938): (1) Uninfested, (2) with from 1 to 20 scale insects, (3) with from 21 to 50 scale insects and (4) with more than 50 scale insects.

The percentage of fruits infested from each sample of 50 oranges was computed. As there were five groups of trees for each treatment, the percentages were averaged, and these mean percentages are given in table 1. The scale population estimates have been derived by calculating each fruit in the 1-to-20 class as bearing one scale, each in the 21-to-50 as carrying 21, and each in the more-than-50 as having 51 scales. These minimum values were then totaled for each sample

was also some increase where ammoniacal copper carbonate was used, but this difference was less than the usually accepted level of significance. The infestations of the Florida red scale were lighter and more variable than those of the purple scale, but much the same responses were noted. Both Bordeaux mixture and hydrated lime spray produced highly significant increases in infested fruits. Low-residue ammoniacal copper carbonate gave increase of lesser extent, and of doubtful significance. However, when the red scale populations were compared, the experiment showed moderate increases for the ammoniacal copper carbonate and the hydrated lime plots and highly significant increases for the Bordeaux mixture plots.

With both the purple scale and the Florida red scale the significant infestation and population increases were associated with the presence of the hydrated lime in the mixtures rather than with the copper. The hydrated lime was present in the Bordeaux mixture of plot 1 and also in the mixture used in plot 2, and is

largely responsible for the heavy residues left on leaves and fruits of these plots. In the case of the ammoniacal copper carbonate spray the copper was present in sufficient amounts and adhered long enough to eliminate the entomogenous fungi, but the residue on the leaves and fruits was light and scale build-up was nonsignificant. We cannot be sure whether this slight increase shown by the results for plot 3 was from the copper, from the light residue, from sampling errors or from all together.

CONCLUSION.—It is quite clear that heavy residues from sprays containing calcium hydroxide produced significant scale insect increases in citrus trees and that presence or absence of copper was unimportant. The experimental results suggest that a partial solution of the problem of scale build-up after Bordeaux mixture might be had by reducing the residue-leaving hydrated lime in the spray to as low a quantity as horticultural or pathological considerations may permit.—4-1-39.

LITERATURE CITED

Fawcett, H. S. 1911. Stem-end rot of citrus fruits. Fla. Ag. Exp. Sta. Bul. 107: 17.

Osburn, Max R., and Herbert Spencer. 1938. Effects of spray residues on scale insect populations. JOUR. ECON. ENT. 31(6): 731–2.

Spencer, Herbert, and Max R. Osburn. 1938. Citrus insect projects of the Orlando Laboratory. JOUR. ECON. ENT. 31(6): 728–30.

Thompson, W. L. 1938. Control of purple scales and whiteflies with lime sulphur. *In* Rept. Fla. Ag. Exp. Sta., 1936–37: 131–2.

Winston, J. R., and W. W. Yothers. 1921. Bordeaux–oil emulsion spray. Fla. State Hort. Soc. Proc., 1921: 145–9.

Winston, John R., John J. Bowman and W. W. Yothers. 1923. Bordeaux–oil emulsion. U. S. Dept. Ag., Dept. Bul. 1178. 24 pp., 3 figs.

Control of the Purple Scale and the Florida Red Scale

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Two of the most important insect pests of citrus in Florida are the purple scale, *Lepidosaphes beckii* (Newm.), and the Florida red scale, *Chrysomphalus aonidum* (L.). The purple scale, which attacks all portions of the tree, is widely distributed over the citrus belt and is usually of major importance every year in some sections. The Florida red scale ordinarily attacks only the leaves and fruits, and is usually more injurious along the lower east coast of Florida, but at times outbreaks in other sections of the citrus area may become serious. Yothers (1918) recommended the use of a paraffin oil emulsion at an oil strength of 1 per cent for the control of scale insects on citrus. Yothers (1922) later found that a single application of oil emulsion at an oil strength of 1 per cent was unsatisfactory in controlling the Florida red scale, but two applications at this strength 6 weeks apart gave control; also single applications at strengths of 2 and 3 per cent were satisfactory, but there was some shadowing or discoloration of fruit. Yothers (1918) and Thompson (1935) reported that some control of scale insects was obtained with the use of sulfur sprays, but they did not recommend these sprays for heavy infestations. Within the last few years combination sprays of lime sulfur plus wettable sulfur and lime sulfur plus dry lime sulfur have been recommended for the combined control of citrus rust mites and light infestations of scales.

EXPERIMENTAL PROCEDURE.—During 1938 an experiment was performed at Orlando, Fla., in which a sulfur spray was compared with an oil spray for the control of heavy and light infestations of the purple scale and the Florida red scale. The sulfur spray consisted of 2 per cent lime sulfur solution to which had been added 5 pounds of wettable sulfur per 100 gallons of water. An oil spray of 1.6 per cent was made from an emulsion containing 83 per cent of oil of light-medium volatility and having an unsulfonated residue of 92 per cent. Early in 1938, in a grove of 10-year-old Parson Brown orange trees, 60 trees had been arranged into 4 plots of 15 trees each. Two of these plots had received applications of sprays leaving heavy lime residues, and in these trees

* The author wishes to acknowledge the helpful suggestions of B. A. Porter and F. M. Wadley regarding the presentation of data in this paper.

heavy, rather uniform infestations of the scale insects had developed. The third had been sprayed with a mixture which produced a medium infestation; the fourth was left unsprayed and in this the infestations remained rather light.

In July each of the four plots described above was split into three groups, making a total of 12 plots of five trees each. Trees of each plot were well distributed over the grove to make the results available for statistical analysis. On July 8, five trees from each of the four original plots (20 trees in all received a spray of lime sulfur solution 2 gallons plus wettable sulfur 5 pounds per 100 gallons of water; a second similar group received the 1.6 per cent oil spray; and the remaining group of 20 trees was left unsprayed. The sulfur and the oil sprays were applied at 400 pounds pressure with a single-nozzle spray gun equipped with a disk having a seven-sixty-fourths-inch opening. Every effort was made to cover all portions of the trees thoroughly. An average of 8.4 gallons of material was applied to each tree receiving the sulfur spray, and each tree sprayed with oil got an average of 7.2 gallons.

At harvest time, the last week in October, samples of 50 fruits from each of the five trees in each plot, 250 fruits per plot, were examined for scales. Fruits were recorded in the following classes: (1) uninfested, (2) with 1 to 20 scale insects, (3) with 21 to 50 scale insects and (4) with more than 50 scale insects. For presentation all fruits recorded in the 1–20 group are classed as having 1 scale each, all in the 21–50 group as having 21, and all in the more-than-50 group as having 51. It was not practical to obtain exact counts of the total scale populations, but the estimates used here are conservative and believed to be adequate for comparative purposes. The minimum total population indicated in this way is given in table 1. The fruit-infestation data were analyzed statistically by the method of analysis of variance.

Table 1.—Effect of lime sulfur and oil sprays on infestations of the purple scale and the Florida red scale in orange trees.

Original Plot	Applications*	Scale Insect Populations	
		Purple Scale, Number	Florida Red Scale, Number
1	a. None	10,747	2,467
	b. Lime sulfur 2 gallons plus wettable sulfur 5 pounds	3,499†	3,555
	c. Oil, 1.6 per cent	429†	518
2	a. None	5,821	422
	b. Lime sulfur 2 gallons plus wettable sulfur 5 pounds	3,090‡	1,368
	c. Oil, 1.6 per cent	738†	591
3	a. None	1,219	396
	b. Lime sulfur 2 gallons plus wettable sulfur 5 pounds	252†	896
	c. Oil, 1.6 per cent	136†	28
4	a. None	537	8
	b. Lime sulfur 2 gallons plus wettable sulfur 5 pounds	186‡	24
	c. Oil, 1.6 per cent	99‡	11

* Amounts are given per 100 gallons of spray.
† Difference from unsprayed trees highly significant.
‡ Difference from unsprayed trees significant.

EFFECT OF THE SPRAYS ON PURPLE SCALE POPULATIONS.—In all the four plots receiving the sulfur spray there was a reduction of purple scale population as compared with that in plots receiving no control treatment. Plot *1b* showed a highly significant reduction when compared with plot *1a*. Plot *2b* showed a significant decrease when compared with plot *2a*. The reduction in the infestation in plot *3b* over that found in plot *3a* was highly significant. Also in plot *4b* there was a significant decrease in infestation when compared with that in plot *4a*.

With the oil spray a highly significant reduction of purple scale was obtained in

plots *1c*, *2c* and *3c* compared with check plots *1a*, *2a* and *3a*, respectively. Also there was a significant reduction of scale population in plot *4c* over that in plot *4a*. The oil spray was consistently more effective than the sulfur spray in reducing purple scale infestations, as is shown by comparing the *c* plots with the respective *b* plots.

EFFECT OF THE SPRAYS ON FLORIDA RED SCALE POPULATIONS.—The sulfur spray was ineffective in reducing populations of the Florida red scale in all four plots. An increase in the number of scales was recorded in each case where sulfur was used, but these increases were not significant.

With the oil spray a reduction of red scale population was obtained in plots *1c* and *3c* when compared with those recorded in plots *1a* and *3a*, but these reductions were not significant. In plots *2c* and *4c* red scale populations were slightly greater than in the respective control plots, *2a* and *4a*, but these increases were not significant. The variation of red scale infestation throughout the plots may have been responsible for the inconsistent results obtained with the sulfur and oil applications.

SUMMARY.—Early in 1938 plots of Parson Brown orange trees received sprays which increased infestations of the purple scale, *Lepidosaphes beckii* (Newm.), and the Florida red scale, *Chrysomphalus aonidum* (L.). In July a spray of lime sulfur 2 gallons plus wettable sulfur 5 pounds per 100 gallons of water and a 1.6 per cent oil spray were applied to representative plots of trees that had received the early sprays. One application of the sulfur spray was effective in reducing purple scale populations in all plots and totally ineffective in reducing infestations of the red scale. One application of the oil spray reduced purple scale infestations to a greater extent than did the sulfur spray, but it was not satisfactory in decreasing infestations of the Florida red scale.—4-1-39.

LITERATURE CITED

Thompson, W. L. 1935. Lime sulfur sprays for the combined control of purple scale and rust mites. Fla. Ag. Exp. Sta. Bul. **282**. 38 pp.

Yothers, W. W. 1918. Spraying for the control of insects and mites attacking citrus trees in Florida. U. S. Dept. Ag. Farmers' Bul. **933**: 30–1.

Yothers, W. W. 1922. Spraying for the control of the Florida red scale. Proc. Fla. State Hort. Soc. **1922**: 63–7.

Habits of the June Beetle, *Phyllophaga lanceolata* (Say) in Iowa*

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Previous to the summer of 1934 not more than a half dozen specimens of *Phyllophaga lanceolata* (Say) had been recorded in Iowa; these were from Ames and Sioux City. On June 13, 1934, William Reis, a farmer, residing near Murray, Clark County, Iowa, sent several June beetles to Iowa State College for determination. The attention of the farmer was attracted to a swarm of insects settling on the ground; he stopped to investigate and much to his surprise found the ground and plants covered with beetles. Subsequent field examinations revealed many pastures in Clark County infested with *P. lanceolata*. In the more favorable feeding areas, a population of 15 to 20 beetles per square foot was not uncommon.

RANGE.—This insect has been reported from New Mexico, Colorado, Texas, Oklahoma, Missouri, Kansas, Nebraska, South Dakota, Iowa and Illinois. It is preponderantly a southwestern species, and in Kansas and Oklahoma has been an important pest of wheat. The abnormally low rainfall of southern Iowa beginning in 1930 may account for the present abundance of this beetle, although its inconspicuous coloration may have served

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to delay its discovery and consequent control measures against it.

The females, generally referred to in the literature as wingless, have a pair of abbreviated hind wings that are useless for flight. The males are much smaller and have well-developed flight wings.

DAMAGE TO CROPS.—Both larval and adult stages attack cultivated plants. The adult is known to feed upon cobs of corn (Cockerell 1895); collards (Howard 1900); and clover, alfalfa, wheat and oats (Hayes 1919). Hayes enumerated 27 different plants upon which the adults normally feed in the field. Observations in Iowa show that the species is a general plant feeder. Food plants are listed below, those marked with an asterisk having been reported by other workers.

Timothy, *Phleum pratense* L.
Bluegrass, *Poa pratensis* L.
*Corn, *Zea mays* L.
Osage orange, *Maclura pomifera* (Raf.)
Mulberry, *Morus alba* L.
Knotweed, *Polygonum* spp.
Sheep sorrel, *Rumex acetosella* L.
Purslane, *Portulaca oleracea* L.
Dewberry, *Rubus canadensis* L.
Cinquifoil, *Potentilla canadensis* L.
Wild Rose, *Rosa pratincola* Greene
*Willow, *Salix* sp.
*White clover, *Trifolium repens* L.
*Red Clover, *T. pratense* L.
Soybeans, *Glycine hispida* Maxim.
Wild morning glory, *Convolvulus sepium* L.
Potato, *Solanum tuberosum* L.
Mullin, *Verbascum thapsus* L.
Blue vervain, *Verbena hastata* L.
Pumpkin, *Cucurbita pepo* L.
Snowberry, *Symphoricarpos occidentalis* Hook.
Compass plant, *Silphium laciniatum* L.
Small ragweed, *Ambrosia artemisiifolia* L.
Greater ragweed, *A. trifida* L.
Purple cone flower, *Brauneria purpurea* D.G.
Artichoke, *Helianthus tuberosus* L.
Thistle, *Cirsium* spp.
Dandelion, *Taraxacum officinale* Weber

In pastures, *Polygonum aviculare* L. appeared to be one of the main food plants for the adults; it was the most common weed in the area where the beetles were emerging in large numbers. Two cases of moderate to severe damage to soybeans were observed, one being on soybeans planted in hills of corn, the other on a field of soybeans grown for seed. The mixture of corn and soybeans was planted in sodland which had been plowed in the early spring. Defoliation of the bean plants was rather general over the entire field, and most severe on the higher ground. Injury to the corn was negligible. In the exclusive planting of soybeans, damage was confined largely to ten or twelve rows of the beans nearest a bluegrass pasture.

Grub damage in pastures occurred in the higher ground, particularly on hilltops and hillsides. The grass had been replaced by weeds in the scattered areas where it had been destroyed by the grubs.

DIURNAL HABITS.—The adults of *Phyllophaga lanceolata* are strictly diurnal. Activity begins at daylight when they emerge to feed and mate. By 7 in the evening, they have usually again secreted themselves in the soil. If the day is hot and sunny, the beetles start "digging in" about 10 o'clock and, by noon, only a few may be found above ground. The greatest number are visible between 8 and 10 o'clock in the morning. Adults removed from the soil during the day were found 2 to 6 inches deep.

SEXUAL ACTIVITIES.—On June 25, at 8:25 A.M., numerous males were seen flying from various directions and suddenly alighting on the ground around a female. The first male to arrive almost instantly succeeded in mating with her. Simultaneously many other males sought females which seemed to be giving off a sex-attractant. During the next few days many similar flights were observed, largely between 8:30 and 10:00 A.M. No coition was observed before 6:30 nor after 11:30 A.M. On many occasions, males were noted feeding, apparently unconcerned, on the same leaf or plant with a female until a female extruded her genitalia. Immediately males within a radius of 15 to 20 yards flew toward her.

During the early morning hours, the males fed little but spent most of the time clinging to weeds and other vegetation with their heads pointed upward, antennae extended, and the lamellae of the antennal club separated.

Exposure of a smashed female initiated flights of males, but produced no visible

response from the females. Crushed males produced no apparent response from either sex.

The diurnal proclivities of these beetles were especially evident on partly cloudy days, in increased activity during intervals of bright sunlight. A female crushed and tossed on the ground when the sun was obscured by a cloud attracted only a few nearby males, but, when the sun reappeared, numerous males became active and flew toward the injured female.

RESPONSE TO AROMATIC COMPOUNDS.—The following compounds were tested to determine whether they would attract adults in the field: metyl salicylate, ethyl butyrate, butyl acetate, methyl phenyl acetate, saligenin, isoamyl mercaptan, vanillyl alcohol, allyl alcohol, piperonal, isoamyl alcohol, heptaldehyde, benzaldehyde, anisaldehyde, anisole ethyl benzoate, ethyl anisate, allantoin, allylamine, acetamide, geraniol, eugenol, isoeugenol, eugenol methyl ether, oil of wintergreen, and isoamylamine. The last named was the only one of these compounds that proved attractive to the males, and none of them seemed to stimulate the females. Isoamylamine produced a male response similar to that made to crushed or to sexually active females.

Table 1.—The number of eggs dissected from 10 female *Phyllophaga lanceolata* collected in the field, 1934.

Beetle	Number of Eggs	Beetle	Number of Eggs
1	26	6	15
2	37	7	14
3	29	8	28
4	38	9	25
5	25	10	36
Total	—	—	373
Average number of eggs			27.3

The crushed and receptive females appeared to produce an emanation or odor that was rapidly disseminated by air movement, as male activity was always greater on the leeward side of the female. The same type of response was secured when isoamylamine was released. When there was no breeze, males from all sides for a distance of 15 to 20 feet would fly toward the point of origin of the attractant. In a breeze, only male beetles that were near (3 to 10 feet away, depending upon the velocity of the wind) were attracted from the windward side, whereas, those on the leeward side would come from a distance of 30 to 40 feet. On one day, when there was a strong wind, isoamylamine stimulated male beetles to activity as far away as 50 to 75 feet, but the wind velocity was so great that only a few were able to reach the chemical.

SEASONAL ABUNDANCE.—By the first of July the females became more abundant in the open pastures, whereas the males tended to congregate on the taller vegetation. The beetles were most numerous on June 26, they were scarce by July 3 and by July 24 none could be found alive.

OVIPOSITION.—Ten females dissected June 26 contained from 14 to 38 eggs, averaging 27.3 each, table 1. As oviposition was already in progress, these figures may not accurately indicate the maximum number of eggs. Hayes (1919) reported that two isolated females laid 9 and 15 eggs, respectively.

Female beetles were caged over soil, placed in a screened insectary and the eggs counted morning and evening for a week. They laid eggs freely throughout the 24 hours. A slightly greater number of eggs was found in the morning, but the difference in the number laid by night and by day was not significant, an indication that oviposition may be independent of the time of day.

The beetles in one of the cages consistently produced more eggs than the others and it was found that the soil in this inclosure was moister than that in the other cages. A check on this observation was made by experiment. Two thousand grams of air-dry soil was placed in each of nine battery jars; to one of these no moisture was added, while water was thoroughly mixed into the soil in the remaining jars to form a series in which each successive jar contained 100 grams more water. Twenty-five female beetles were put in each jar, which was then covered with a glass plate to prevent evaporation. Food and water were available in each jar for the beetles. The experiment was repeated, and in both instances most eggs were laid in the soil containing 500 grams of water, table 2.

Each egg was laid loosely in a cavity in the center of an irregular ball of soil about one-fourth to one-half inch in diameter. Several of these balls were usually found

Table 2.—Number of eggs laid by 25 *Phyllophaga lanceolata* in soils of varying moisture content, 1934.

Grams of Water Added to 2,000 Grams of Soil	Number of Eggs Laid		Total Number of Eggs
	Experiment No. 1	Experiment No. 2	
0	0	0	0
100	0	0	0
200	32	15	47
300	70	64	134
400	80	86	166
500	143	128	271
600	93	114	207
700	76	84	160
800	51	6	57
Total	545	497	1,042

in a cluster. As the embryo developed, the egg increased in size and filled the cavity.

In the jar with moisture of less than 500 grams, the eggs were found free in the soil, because there was not sufficient moisture to form balls. In the soils containing 700 and 800 grams of water, again the balls were not found, as the soil was too moist for them to remain separated.

The egg cells were best developed in the jars to which 500 grams of water had been added. Since the greatest number of eggs was deposited in these jars, the soil in them apparently most nearly approached the optimum as to moisture. Judging from this experiment it seems quite possible that soil moisture may be an important factor in causing grubs to be "spotted" rather than uniformly distributed in a field.

SUMMARY.—*Phyllophaga lanceolata* (Say) was found in numbers in southwest Iowa for the first time in 1934. Twenty-four host plants were added to the list for this species. Damage to corn and soybeans by the adults was observed, and to blue grass pastures by the larvae. Crushed females and the chemical isoamylamine strongly attracted the males as also did sexually receptive females. Ten females contained an average of 27 eggs each, with a range of 14 to 38. The beetles oviposited by day as well as by night. In a series of jars each containing 2,000 grams of soil moistened with different amounts of water, the greatest number of eggs was laid in the jars with 500 grams of added water.—4-1-39.

LITERATURE CITED

Cockerell, T. D. A. 1895. Entomological observations in 1894. N.M. Ag. Exp. Sta. Bul. 15: 1–82.
Hayes, W. P. 1919. The life cycle of *Lachnosterna lanceolata* Say. JOUR. ECON. ENT. 12: 109–17.
Howard, L. O. 1900. Notes from correspondence. Injury by wingless May beetles in Texas. U. S. Dept. Ag. Bur. Ent. Bul. 22, n.s.

Migration and Bionomics of White Grubs in Iowa, 1930–1935*

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Seasonal migration of white grubs and hibernation depths for larval and adult *Phyllophaga* were studied in Iowa (1930–1935) to determine when these insects would be most vulnerable to mechanical control measures. Incidental to these observations, data were secured on the transformation periods of the grubs, and on the depth of pupation of their *Tiphia* and *Elis* parasites. The records were collected largely in bluegrass pastures although some were from timothy meadows and from cornfields.

METHODS.—The method of study was to remove the soil from plats 2 feet square in vertical slices, so that the depth of the larvae, adults and parasites could be measured. The excavation was extended at least 1 foot deeper than where the lowest specimen was found. No attempt was made to identify the species, although future work no doubt will indicate differences in the bionomics of the species. The *Phyllophaga* in the Decatur County area were largely *micans* and *hirticula*, and in the Floyd County area *hirticula* and *tristis*. Three-inch running averages were used in all of the graphs.

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SOIL TYPES.—All data for 1930 to 1932* were from Decatur County (near Leon, Iowa) and for 1933 and 1934 from Floyd County (near Charles City, Iowa). The soil type in the Decatur County area was a dark brown, loose loam, averaging 6 to 10 inches in depth and changing somewhat abruptly into a subsoil of yellow, heavy, tenacious and gritty clay. The soil of the Floyd County area was a dark brown to black silt loam, 10 to 12 inches deep, passing rather gradually into a gray, silty loam and from that at 18 to 20 inches to a heavy, brown, clay subsoil. In the Decatur County tract the impervious layer of clay subsoil was not so deep and was in general more compact and tenacious than in the Floyd County area.

FALL MIGRATION AND HIBERNATION.—McColloch & Hayes (1923) reported two complete overturns of soil temperatures during the year, that cause the white grubs to migrate down in the fall and up in the spring. While no soil temperature records were kept in the studies here reported upon, the sudden and comparatively rapid up and down migrations of the grubs were observably correlated rather closely with variations in air temperature.

In 1930, the first hard freeze occurred the night of October 15. Three days previously, all of the grubs were feeding 1 to 2 inches under the surface of the ground, and by October 17 migration was well under way, with grubs at a maximum depth of 19, a minimum of 1 and a mean of 7.4 inches. The rate of soil penetration was thus surprisingly rapid. The migration was complete by November 14, when the grubs were in hibernation cells at the ends of their tunnels. Observations indicated that these overwintering cells were formed by the larvae pressing the soil outwards with their heads and bodies. The grubs seldom penetrated more than 2 or 3 inches into the hard subsoil. Fall movement downward from brood *A* in 1932 (Decatur County) began October 23 and was completed by November 17. In 1933 (Floyd County) the migration began October 30 and was ended by November 16.

In order to investigate further the rate of migration, larvae collected October 17, 1930, were liberated in an unplowed field. These grubs were placed in 1-foot-square plats in four groups, each containing 25 individuals. They were covered with a thin layer of soil to prevent birds from molesting them, and were examined at 24-hour intervals to determine the depths penetrated. The movement was almost vertically downward, most of the grubs being found in the 1-foot-square area, and all within an 18-inch square. Previous observations on the rate of migration under natural conditions were corroborated when this migration appeared complete by the third day, table 1.

Table 1.—Rate of grub migration in Iowa, 1930.

HOURS	DEPTH IN INCHES		
	Minimum	Maximum	Mean
24	1	10	5.3
48	4	15	9.4
72	2	20	11.9
96	5	18	11.1

In 1930 (Decatur County), the maximum depth of hibernation under bluegrass sod was 22 inches, the minimum 7 and the mean 14.5; in timothy the maximum was 24, the minimum 13 and the mean 15.6; and in corn the maximum was 22, the minimum 10 and the mean 19 inches. In 1932 (Decatur County) the grubs migrated down beneath bluegrass sod to a maximum depth of 24 inches, a minimum of 9 and a mean of 14.5. In 1933 (Floyd County) the maximum depth attained under bluegrass was 30 inches, the minimum 9 and the mean 17.9; in cornfields the maximum was 30, the minimum 1 and the mean 17.5, fig. 1. These data indicate that after migration the grubs are too deep to be affected by practical mechanical control methods; hence the middle of October, before winter quarters have been reached, would be the latest that such methods could be successfully used.

SPRING MIGRATION.—The upward migration in 1931 started between April 7 and 16, and was completed by May 19. In 1933 the movement began between April 1 and 9 and was ended by May 10. The spring migration of 1934, which started between April 27 and May 5, was

* Data for the years 1930–1931 have been previously published in part (Drake, Travis & Collins 1931), but are abstracted here for comparison with those for the years 1932–1935.

peculiar in that many of the larvae pupated in their hibernation cells without the usual third year period of feeding. Since migration is seldom complete before the middle of May, mechanical control methods are ineffective before that time.

In the spring of 1934 (Floyd County) all larvae and adults to a depth of 14 inches were found dead, having apparently succumbed to cold weather. Except in this one instance, no *Phyllophaga* were found during the period 1930–1935 whose death

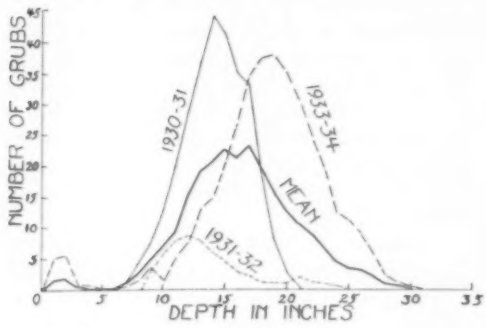

FIG. 1.—Hibernation depths for grubs brood *A*. 1930–1931, 280 individuals, mean depth 14.5 inches; 1931–1932, 62 individuals, mean depth 14.5 inches; 1933–1934, 373 individuals, mean depth 17.9 inches; average mean depth in Iowa of 715 individuals, 16.0 inches.

could be attributed to low temperature, despite the fact that some larvae overwintered in Decatur County (1930–1931) at a depth of only 3 inches.

Mortality appears to be high among the larvae of *Phyllophaga*. Hayes & McColloch (1928) report a 68.7 per cent loss in grubs collected from fields and kept in cages. Table 2 records all individuals of brood A (larvae, pupae and adults) found in digging the 2-foot-square plats in a bluegrass pasture, from April to October, 1931. Since the larvae appeared to be uniformly distributed over the area, a high death rate is indicated. Dead individuals unearthed during this period accounted for the decrease in the living population. It may be observed that the mortality shown in table 2 was low during the interval of upward migration until the pupation period, when there was a sharp drop in the number of living *Phyllophaga* per plat.

In Decatur County, farmers claimed that their crops had been seriously injured 2 years out of every 3 from 1919 to 1930, inclusive. In the fall of 1930, thousands of

Table 2.—Seasonal decrease in a white grub population, Iowa, 1931.

Month	Number Plats	Total Brood *A*	Brood *A* Per Plat	
			Mean	Range
April	13	278	19.07	15–21
May	19	286	15.05	10–23
June	10	179	17.90	15–20
July	14	71	5.07	3–9
August	16	71	4.43	2–11
September	18	83	4.61	1–12

acres of corn, timothy and bluegrass were damaged or destroyed in Decatur and adjacent counties.

There was the expected emergence of hordes of June beetles in the spring of 1932, yet during the next 2 years there seemed to be no unusually large infestations of grubs in these counties.

It is known that the beetles oviposited and that many of the eggs hatched. At the time the beetles were depositing their eggs and during the hatching period, however, there was a severe drought in the region. The newly hatched grubs appeared unable to penetrate the dry, hard ground and they did not feed, as evidenced by the absence of food materials in their digestive tracts. Shortly after hatching many young grubs were found dead and desiccated. None of the mortality appeared due to disease, but instead seemed to be a result of the drought. Moisture conditions were more favorable in the northern and northeastern portions of the state, and there the grub populations were dense. For the time, *Phyllophaga* larvae practically disappeared from the southern droughty affected parts of Iowa.

TRANSFORMATION.—In 1931 (Decatur County), brood *A* larvae began their downward migration between July 1 and July 6 preparatory to transformation. The first prepupae were observed July 2, and the maximum percentage of grubs in this stage of development was found August 1. No prepupae were detected after September 8. Pupation began July 24, the maximum percentage in this stage was noted September 1 and the last pupa was observed September 19. The first adults were seen August 20, fig. 2, the last between September 20 and 24.

As previously stated, the spring migration of brood *A* (1934) was peculiar in that many of the overwintering larvae did not migrate, but pupated in their hi-

bernation cells. Prepupal stages were difficult to distinguish from hibernating grubs because neither showed food material in the rectum. The softness and the opaque-white color of transforming grubs, however, were useful criteria for their rec-

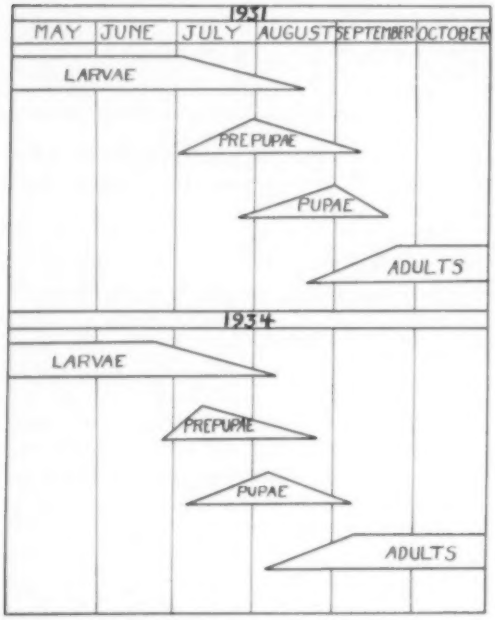

FIG. 2.—Graph illustrating the transformation periods of June beetles in Iowa.

ognition. In 1934, prepupae were first found June 28, the greatest percentage of the grubs in this stage July 12 and the last August 24. The first pupa was seen July 6, the greatest percentage in this stage August 6 and the last September 14, fig. 2.

The maximum depth of pupating larvae in 1931 (Decatur County) was 17 inches, the minimum 3 and the average 11.5. In 1934 (Floyd County) the maximum depth for pupae was 31 inches, the minimum 2 and the mean 19.1, fig. 3. A few pupae of brood *C* were found in the fall of 1930 (Decatur County) and the maximum depth for these was 15 inches, the minimum 5 and the average 11.2.

The irregularities in the curves for the pupation depths for brood *A* in 1934 may be due to the circumstance that many of the grubs did not leave their hibernation cells before pupation, rather than to the small samples.

Upward migration of adults preparatory to flight occurred April 3–10, 1931 for brood *C* and March 27–April 1, 1932, for brood *A* in Decatur County. Adults move upward in the spring earlier than the grubs. Flight usually starts so early that the first feeding is on buds before the leaves of the host plants have expanded.

Criddle (1918) in Canada and McColloch & Hayes (1923) in Kansas reported that certain *Phyllaphaga* migrate downward from their pupal cells in winter. No Iowa species was observed to do so, the cast larval and pupal skins being invariably found in the hibernation cells. The only movement of the adults in the soil appeared to be nearly straight upward prior to emergence. The insects did not burrow deeper even though the winter of 1933–1934 was so cold in Floyd County that all larvae and adults to a depth of 14 inches were killed.

PARASITE PUPATION DEPTHS.—While digging for June beetles, the author col-

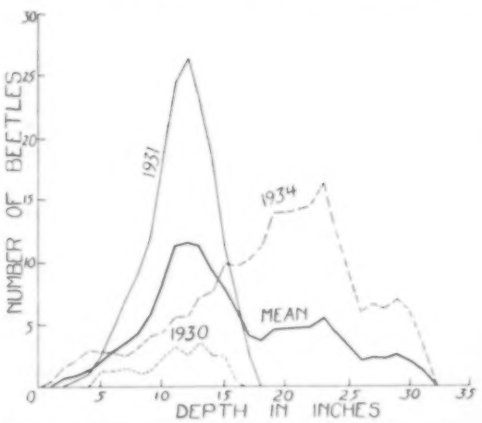

FIG. 3.—Transformation depths of June beetles. Brood *C* 1930, 25 individuals, mean depth 11.2 inches; brood *A* 1931, 169 individuals, mean depth 11.5 inches; brood *A* 1934, 226 individuals, mean depth 19.1 inches; average mean depth in Iowa of 420 individuals, 16.6 inches.

lected 65 pupae of *Tiphia* and *Elis* parasites in 1930, and 163 in 1931. Records concerning the hibernation depths of these hymenopterans by McColloch, Hayes & Bryson (1928) obtained from 1920 to 1926, and involving 103 individuals, revealed cocoons at depths ranging from 2 to 23 inches with yearly averages varying from 9.9 to 17.2 inches, the average being 11.1 inches for the entire period.

In 1930 the maximum depth of these pupae in Iowa was 16 inches, the mini-

mum 1 and the mean 7.3; in 1931 the maximum was 17 inches, the minimum 3, and the mean 12.3, fig. 4. Irregularities in the curve for 1930–1931 and the shallow pupation depths are due not only to the small numbers represented, but also probably to the drought conditions prevailing that winter in southern Iowa.

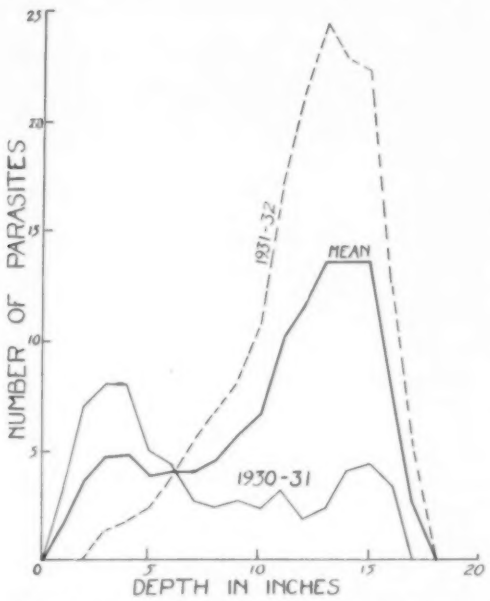

FIG. 4.—Pupation depths of *Tiphia* and *Elis* parasites in Iowa; 1930–1931, 65 individuals, mean depth 7.3 inches; 1931–1932, 163 individuals, mean depth 12.3 inches; average mean depth 228 individuals, 10.8 inches.

SUMMARY.—In Iowa (1930–1935), the first downward movement of white grubs for hibernation immediately followed the first cold weather in the fall. Downward migration began October 15 to 30 and was completed by November 14 to 16. Individual grubs collected during the first cold weather, October 17, 1930, were able to dig in unplowed ground as deep as 20 inches in 72 hours.

Hibernation of the grubs occurred at a mean depth of 16 inches, and pupation and overwintering of the adults at 16.6 inches. The depths of hibernation and pupation were somewhat deeper in Floyd than in Decatur County, apparently because of the greater depth to the heavy clay subsoil in Floyd County rather than to climatic or specific differences.

The upward migration started from April 7 to May 5 and was completed May 10 to 19. Probably because of drought conditions in the spring of 1934, all of the grubs did not migrate upward to feed in the third year, but pupated in their hibernation cells.

A study of their life cycle in the field showed that the grubs in Iowa ceased feeding and migrated downward for transformation from July 1 to 15. Prepupae were found June 28 to August 24; pupae from July 6 to September 19; and the adults August 4 to 20. Adults overwintered in the pupal cells and issued from the soil March 27 to April 10.

Tiphia and *Elis* parasites were found pupating at a mean depth of 10.8 inches.

If mechanical control measures are to be attempted, they must be used during the period when the grubs are near the surface of the soil. The data here presented indicate that in Iowa this should not be later than the middle of October nor earlier than the middle of May.—4-1-39.

LITERATURE CITED

Criddle, N. 1918. The habits and control of white grubs in Manitoba. Ag. Gaz. Can. 5: 449–54.

Drake, C. J., B. V. Travis and E. V. Collins. 1931. A preliminary report on the control of white grubs with a rotary plow. JOUR. ECON. ENT. 25: 199–207.

Hayes, William P., and J. W. McColloch. 1928. Ecological studies of Kansas Scarabaeid larvae (Coleop.). JOUR. ECON. ENT. 21: 249–60.

McColloch, J. W., and William P. Hayes. 1923. Soil temperature and its influence on white grub activities. Ecol. 4: 29–36.

McColloch, J. W., William P. Hayes and H. R. Bryson. 1928. Hibernation of certain Scarabaeids and their *Tiphia* parasites. Ecol. 9: 34–42.

THE California quarantine proclamation with reference to the cotton boll weevil and pink bollworm was modified effective June 16, 1939, to permit the entry of used bagging, wrappers and containers from infested area, subject to treatment or processing on arrival, and also the entry of Spanish moss that has been processed.

W. A. MCCUBBIN, who for the past 4 years has been in charge of the enforcement of foreign plant quarantines and certain domestic plant quarantines relating to the shipment of plants and plant products from Porto Rico to the mainland, was transferred to Washington, D. C., on July 6, 1939. Mr. McCubbin has been succeeded by W. T. Owrey.

Responses of the Silverfish, *Lepisma saccharina* L., to Its Physical Environment*

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The silverfish is a common household pest in many parts of the world. This insect is nocturnal and for that reason frequently becomes numerous before being observed. The pest is quick and active and when disturbed darts under or behind some object or into a crevice.

DISTRIBUTION.—*Lepisma saccharina* L. is distributed widely through the humid portions of the temperate and tropical zones. It can maintain itself in dry portions of these zones if in a humid environment such as exists in basements of houses and frequently around water pipes and drains. Likewise it may penetrate into and maintain itself in cold climates if suitable temperature and moisture conditions are available. Such environments commonly exist in human habitations.

FOOD HABITS.—The silverfish commonly is reported as living upon starchy materials almost exclusively (Whitmarsh 1912, Dietz 1912, Marlatt 1915, Mohr 1923, Morita 1926, McDaniel 1928, Gibson & Twinn 1929, Marcovitch 1933, Haseman 1935, Reichmuth 1936, Back 1937, Turner 1937). Frequently they attack starched cloth and paper, especially glazed types of paper such as are used in record books, filing cases and books. Sizing used for such papers frequently contains animal matter, and the glue in book bindings is attractive to the pests. Garman (1906, 1917) emphasized the importance of animal matter (protein) in the diet of the pests, and a few papers since have repeated this information (Felt 1917, Chapman 1921, Flint 1922, Mohr 1923, Morita 1926, Davis 1928). Cereals such as whole wheat flour and breakfast cereals are much preferred to starch materials. Animal products, such as fresh dried beef, are eaten eagerly and may be an essential portion of the diet. If fed only whole wheat flour or Mead's cereal for about 2 weeks and then offered fresh dried beef they eat the latter ravenously, fighting among themselves for the food. They are cannibalistic and eat their own cast skins and dead or injured individuals (Garman 1906, Morita 1926).

METHODS OF HANDLING.—The technique of handling the silverfish in cages is the same as that used with the firebrats and was described in an earlier paper (Sweetman 1938).

EGG STAGE.—The eggs of *Lepisma saccharina* are soft and white in color when first laid. Shortly after exposure to the air the color changes to yellow and finally to light brown within a few hours (Dietz 1912). Unexposed eggs do not become as dark as exposed eggs. The eggs at first are fairly plump, but by the time the brown color is assumed they are likely to be somewhat shriveled. The eggs are laid singly or only two or three together. A laying female usually deposits from one to three eggs per day and may deposit on a number of successive days or at intervals of several days or even weeks. Usually the eggs are hidden in crevices or under objects, but occasionally are dropped loosely wherever the female happens to be (Dietz 1912, Sanborn 1919, Back 1931, 1937). The color of the chorion is sufficiently dark that the embryos are not visible at any time preceding hatching. Even when the embryo is fully developed the shriveled condition of the chorion remains, making it difficult to determine if the embryo is alive.

The eggs were exposed in wide ranges of constant temperature and relative humidity. Eggs hatched at temperatures ranging from 22 degrees to 32 degrees C., but the highest percentage hatched at 22 degrees, the lowest temperature at which eggs were exposed. The threshold of development was estimated to be near 15 degrees. Eggs hatched in moisture environments above 50 per cent relative humidity at 22 degrees and 27 degees, but only above 75 per cent at 29 degrees and 32 degrees. The average incubation period varied from 43 days at 22 degrees to 19 days at 32 degrees. Back (1931, 1937), apparently following Morita (1926), states that hatching occurs in from 6 to 10 days in warm weather. This apparent response to temperature was not con-

* Contribution from the Entomological Laboratory of Massachusetts State College, Amherst.

firmed by the writer, however. This difference along with a number of others suggests that Morita either worked with a different species or made faulty observations. The length of the incubation period increased from 1 to 5 days, depending upon the temperature when the relative humidity was below 75 per cent.

NYMPHAL STAGE.—Newly hatched nymphs were exposed in wide ranges of constant temperature and relative humidity until maturation. Maturation of the nymphs occurred at 22 degrees, 27 degrees, 29 degrees and 32 degrees C. in environments with relative humidity above 60 per cent. All of the nymphs died regardless of the moisture conditions at 37 degrees and 40 degrees. The greatest percentage of development occurred in moisture conditions above 75 per cent. The percentage maturing dropped considerably at 32 degrees over that at lower temperature. The age at which maturation occurs is impossible to determine definitely since molting occurs throughout life, and the period varies considerably, depending upon the temperature. A life cycle of 2 to 3 years from egg to adult has been attributed generally to this insect (Sanborn 1919, Mohr 1923, Back 1931, 1937), but reproduction in favorable environments may take place when the insect is only 3 to 4 months of age. Back (1931, 1937), again apparently following Morita (1926), states that maturation occurs in 7 to 9 months in tropical climates. Growth usually continues long after the first reproduction takes place and may continue throughout life.

The newly hatched nymphs are naked, milky white in color, and are more plump and less active than later instars. Following the first molt the nymphs are more slender and much more active. At the third molt they become clothed with scales. The first instar lasts 2 to 4 days; the second 7 to 10 days. Sanborn (1919) reports that the first molt occurs immediately after hatching, but this was not observed to occur. Later instars in favorable conditions last from 2 to 3 weeks.

ADULT STAGE.—Reproduction of the silverfish occurred in environmental temperatures of 22 degrees, 27 degrees, 29 degrees and 32 degrees C. About 20 females with males were exposed in each temperature of the above series. Nearly all of the reproduction occurred above 75 per cent relative humidity and the highest percentage of oviposition took place in environments of 84 to 100 per cent. An average of approximately 100 eggs was laid at 22 degrees and 27 degrees, about 70 at 29 degrees and 1 at 32 degrees. Back (1931, 1937) and Morita (1926) suggest that not more than 10 to 12 eggs are laid by each female. Temperatures much above 32 degrees usually killed the nymphs or adults in a few hours. In natural environments this insect avoids unfavorable conditions and would likely escape from any attempts of control by temperature.

The length of life of the adults varies considerably in different environments. Several of the adults exposed at 22 degrees are still alive and reproducing after about 3½ years. The majority of individuals live about 2 years at 27 degrees, although some attained an age of well over 3 years. A few lived somewhat over 2 years at 29 degrees, while about 1½ years is the maximum at 32 degrees.

COMPARISON WITH THE FIREBRAT.—The silverfish, in contrast with its close relative, the firebrat, requires much lower temperature and higher moisture conditions than the latter pest. Its food habits are very similar to those of the firebrat. The reproductive habits are quite different. While the eggs are hidden in crevices and debris where conditions are favorable, only one to four eggs are laid at a time or on a single day. The firebrat lays a number of eggs in a batch, all within a few minutes.

CONCLUSIONS.—The silverfish is a common household pest which feeds on a number of foods rich in protein, if available, rather than carbohydrates, as commonly reported. The insect develops and reproduces best at temperatures of 22 degrees to 27 degrees C. and relative humidities of 75 to 97 per cent. It is a long-lived insect, frequently attaining an age of well over 3 years, yet it may begin reproduction when only 3 to 4 months old. In favorable environments an average of about 100 eggs may be laid. The incubation period varies from 3 to 7 weeks at temperatures of 22 degrees to 32 degrees. The newly hatched nymphs are naked, but become clothed with scales at the third molt. The silverfish molts throughout life and continues to grow throughout most if not all of its life. The first instar lasts only 2 to 4 days, but after the second or third instar molting occurs every 2 or 3 weeks for the remainder of life.—4-1-39.

LITERATURE CITED

Back, E. A. 1931. The silverfish as a pest in the household. U. S. Dept. Ag. Farmers' Bul. **1665**: 1–5.
Back, E. A. 1937. Silverfish. U. S. Dept. Ag. Leaflet **149**: 1–4.
Chapman, R. N. 1921. Insects infesting stored food products. Minn. Ag. Exp. Sta. Bul. **198**: 59–60.
Cornwall, J. W. 1915. *Lepisma saccharina*, its life history and anatomy and its gregarine parasites. Indian Jour. Med. Res. **3**: 116–34.
Davis, J. J. 1928. Insect problems of the home. Ind. Ag. Exp. Sta. Circ. **150**: 8-9.
Dietz, H. F. 1912. Insects that affect the household and man. Ind. Fifth Ent. Rep. 192–4.
Felt, E. P. 1917. Household and camp insects. N. Y. St. Mus. Bul. **194**: 56.
Flint, W. P. 1922. The control of household insects. Ill. Ag. Exp. Sta. Circ. **257**: 20–1.
Garman, H. 1906. Does the silver-fish (*Lepisma saccharina* L.) feed on starch and sugar? Eighteenth Ann. Meet. Assn. Econ. Ent.; U. S. Dept. Ag. Ent. Bul. **60**: 174–6.
Garman, H. 1917. Household pests and their treatment. Ky. Ag. Exp. Sta. Circ. **15**: 87–90.
Gibson, A., and C. R. Twinn. 1929. Household insects and their control. Can. Dept. Ag. Bul. **112**: 46, n. s.
Haseman, L. 1935. Insect pests of the household. Mo. Ag. Exp. Sta. Bul. **356**: 24–5.
Marcovitch, S. 1933. How to combat certain pests of the household. Tenn. Ag. Exp. Sta. Bul. **147**: 8.
Marlatt, C. L. 1915. The silverfish; an injurious household insect. U. S. Dept. Ag. Farmers' Bul. **681**: 1–4.
McDaniel, E. I. 1928. Cockroaches, silver-fish, and book-lice. Mich. Ag. Exp. Sta. Circ. **101**: 7–10.
Meyer, A. E. 1932. Über Helligkeitsreaktionen von *Lepisma saccharina* L. Zeitschr. f. Wissenschaft. Zool. **142**: 254–312.
Mohr, E. 1923. Biologisches über *Lepisma saccharina* L. Zool. Anz. **56**: 174–81.
Morita, H. 1926. Some observations on the "silverfish" (*Lepisma saccharina* L.) (Thys.). Proc. Haw. Ent. Soc. **6**: 271–3.
Reichmuth, W. 1936. Die Wohnungsfischchen und ihre Bekampfung. Zeitschr. hyg. Zool. Schadl-Bekampf. **28**: 65–71. (Abstract in Rev. App. Ent. **26A**: 37.)
Sanborn, C. E. 1919. The fish moth. Twenty-eighth Ann. Rep. Okla. Ag. Exp. Sta. 43–44.
Sweetman, Harvey L. 1938. Physical ecology of the firebrat, *Thermobia domestica* (Packard). Ecol. Monog. **8**: 285–311.
Turner, N., and B. H. Walden. 1937. Some common household insects and their control. Conn. Ag. Exp. Sta. Bul. **400**: 846–7.
Whitmarsh, R. D. 1912. Insect pests of the household. Ohio Ag. Exp. Sta. Bul. **253**: 133.

Experiments Using Several Insecticides With and Without Wetting Agents and Stickers for Boll Weevil Control

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In South Carolina there is definite need of a substitute for calcium arsenate in control of the boll weevil, *Anthonomus grandis* Boh. There are two reasons for this need. The first, and foremost, is the fear of growers that soil injury will result from applying calcium arsenate to the cotton plants, and the second is the increase in plant lice population which usually follow several successive applications of calcium arsenate and which frequently reduces the yield of cotton below that produced on untreated plants. The evils of calcium arsenate have been widely publicized in the newspapers of the state and, while statements concerning these conditions are not without foundation, they are often exaggerated, and as a result many farmers are hesitant to use the standard recommendations for boll weevil control. During 1938 four experiments were conducted near Florence, S. C., in an effort to find a substitute that would control the weevil and at the same time overcome the objections to the use of calcium arsenate. Each experiment consisted of six treatments replicated six times on one-twentieth-acre plots arranged in a Latin square. The plots in all experiments contained eight rows of sufficient length to make one-twentieth of an acre. Two rows on each side of each plot and 10-foot strips at the ends of each plot were left untreated.

INSECTICIDES TESTED.—The following three groups of insecticides were tested: (1) Calcium arsenate, which was used in each of the four experiments, for comparison with the other insecticides; (2) two nicotine compounds, one containing nicotine bentonite and the other nicotine bentonite plus nicotine tannate; and (3) two cryolite dusts, one a finely ground synthetic cryolite containing 90.8 per cent of sodium fluoaluminate, of which 88 per cent of the particles were less than

10 microns in diameter, and the other a coarsely ground cryolite containing 78.3 per cent of sodium fluoaluminate, of which 35 per cent of the particles were larger than 50 microns in diameter. All these insecticides were applied as dusts, with and without one or more of the following commercial wetting agents and stickers: (1) A sodium salt of an alkylated naphthalenesulfonate (*Vatsol*), (2) a monosodium sulfonate of butyphenyl phenol (*Areskep*), (3) a sulfonated alkylated diphenyl (*Aresket*), (4) a synthetic liquid sticker and spreader (*Lethane*), (5) a dry gum containing a tapioca base. The first four of these were thoroughly mixed with the insecticides at the rate of 1 per cent by weight. The dry gum was mixed at the rate of 5 per cent by weight. One treatment consisted of equal parts by weight of calcium arsenate and calcium carbonate, for comparison with the other five insecticides that were tested without wetting agents or stickers.

It should be stated that the dusting qualities of both cryolites were extremely poor. The coarse cryolite was entirely too coarse, causing an excessive amount to be applied with very little coverage. It was almost impossible to apply the fine cryolite with a rotary hand duster, the dust coming out in spurts and frequently flaking. The addition of wetting agents and stickers in the quantities stated remedied this difficulty somewhat, but the cryolite still had a tendency to flake. None of the wetting agents and stickers tested had any marked effect on the dusting qualities of calcium arsenate or the nicotine compounds.

METHOD OF OBTAINING DATA.—In an effort to obtain a reliable sample of the percentage of infested cotton squares, the following procedure was used for each experiment: All the squares large enough for oviposition on the plants in the tenth hill of each of the four middle rows were examined and the number of squares and the number of punctured squares recorded. The counts were made at 3- to 6-day intervals throughout the season, but only those made after the first poison application in each experiment were used in the seasonal averages. The total number of living and the total number of dead weevils were recorded for each plot.

The white blooms on the six middle rows of each plot were counted at 1- to 6-day intervals throughout the blooming period. The bolls and the plants in the four middle rows of each plot were counted at the end of the fruiting period. The seed cotton produced on 50 feet in the middle of the six middle rows in each plot was picked and weighed.

RESULTS.—The data from these experiments are summarized in table 1.

DISCUSSION OF DATA.—From table 1 it is seen that the only consistent criterion is the average seasonal infestation, as highly significant differences are generally shown between the same treatments in each experiment. This is therefore the most reliable criterion in determining the effect of the insecticides on the boll weevil. The bloom counts also gave a good indication as to the comparative effectiveness of the insecticides. In experiments 1 and 2 the cotton had not reached the peak of fruiting when dusting began and it continued to fruit until late in the season. In experiments 3 and 4 the cotton was past the peak of fruiting when the first poison application was made. Consequently in experiments 1 and 2 there were about twice as many counts as in experiments 3 and 4, and a statistical difference between treatments can be shown. The numbers of living and dead boll weevils, although not lending themselves to statistical analysis, nevertheless give some indication as to the relative value of the insecticides.

Boll counts and yield records may or may not be reliable criteria in determining the relative values of the insecticides, these depending primarily on the effect of the insecticides in building up aphid infestation to an injurious extent. In experiment 2, for example, the average seasonal infestation and bloom counts show a 99-to-1 significance favoring calcium arsenate over the nicotine compounds, yet the yield records fail to show any significant difference between treatments. The boll counts show only a 19-to-1 significance. A heavy aphid infestation developed in the plots that received the calcium arsenate treatments, causing practically all the lower leaves and much of the fruit to fall, whereas there were practically no aphids in any of the plots dusted with the nicotone compounds. In experiments 3 and 4 the plots treated with calcium arsenate and the fine cryolite also developed heavy aphid infestations, whereas those treated with

Table 1.—Summary of experiments using insecticides, with and without wetting agents, against the boll weevil, Florence, S. C., 1938.

Insecticide	Average Number of Pounds of Insecticide Per Acre Application	Average Seasonal Infestation Per Plot, Per Cent	Average Yield of Seed Cotton Per Plot, Pounds	Average Number of Blooms Per Plot	Average Number of Bolls Per Plot	Average Number of Bolls Per Plant	Total Number of Weevils Per Plot	
							Live	Dead
Experiment 1								
	(11 applications)	(15 counts)		(16 counts)			(15 counts)	(15 counts)
Calcium arsenate	9.2	8.40	19.87	1,117	1,713	4.60	136	35
Nicotine bentonite	15.1	18.32	13.57	662	1,106	3.59	175	2
Nicotine bentonite–tannate	11.3	20.00	14.00	587	1,195	3.73	172	0
Fine cryolite	11.3	13.92	17.58	879	1,515	4.43	169	9
Coarse cryolite	22.0	14.79	14.47	732	1,223	3.56	158	3
Calcium arsenate–calcium carbonate	9.8	10.97	19.30	1,044	1,680	4.91	170	31
Minimum significant difference								
For 5 per cent probability	—	4.82	3.34	205	212	—	—	—
For 1 per cent probability	—	6.57	4.55	279	289	—	—	—
Experiment 2								
	(9 applications)	(7 counts)		(17 counts)			(7 counts)	(7 counts)
Calcium arsenate	10.7	12.60	27.23	1,810	2,685	5.54	183	44
Nicotine bentonite	16.5	29.23	26.38	1,004	2,273	4.48	226	4
Nicotine bentonite–tannate	12.3	32.70	23.55	927	1,861	3.95	301	3
Calcium arsenate plus*	10.0	11.85	28.25	1,751	2,951	6.24	170	53
Nicotine bentonite plus*	9.4	28.32	24.73	1,046	2,112	4.36	227	4
Nicotine bentonite–tannate plus†	10.4	33.05	25.05	918	2,272	4.75	291	2
Minimum significant difference								
For 5 per cent probability	—	5.16	9.30	366	635	—	—	—
For 1 per cent probability	—	7.03	12.70	500	866	—	—	—
Experiment 3								
	(7 applications)	(8 counts)		(9 counts)			(8 counts)	(8 counts)
Calcium arsenate	12.0	16.78	17.22	486	1,500	3.64	94	22
Calcium arsenate plus‡	12.1	16.33	18.72	564	1,696	3.85	99	23
Fine cryolite	13.9	22.17	16.07	439	1,406	3.52	151	4
Fine cryolite‡	11.1	17.68	14.12	343	1,348	3.28	74	4
Coarse cryolite	24.0	25.17	13.59	352	1,215	3.16	129	2
Coarse cryolite plus†	27.7	23.57	14.40	404	1,312	3.18	151	6
Minimum significant difference								
For 5 per cent probability	—	3.82	4.21	183	317	—	—	—
For 1 per cent probability	—	5.21	5.74	249	432	—	—	—
Experiment 4								
	(7 applications)	(7 counts)		(9 counts)			(7 counts)	(7 counts)
Calcium arsenate	10.1	16.55	13.98	463	1,350	4.00	117	19
Calcium arsenate plus§	10.8	13.92	12.88	416	1,332	4.19	104	20
Nicotine bentonite–tannate	11.7	22.20	11.75	402	1,150	3.46	125	2
Nicotine bentonite–tannate plus**	11.4	23.37	11.15	357	1,108	3.44	113	3
Fine cryolite	13.1	19.68	12.15	418	1,244	3.79	78	6
Fine cryolite plus§	11.8	21.30	10.68	376	1,166	3.49	113	7
Minimum significant difference								
For 5 per cent probability	—	4.45	2.02	79.4	155	—	—	—
For 1 per cent probability	—	6.07	2.76	108.2	211	—	—	—

* Sulfonated alkylated diphenyl (*Areskel*).
† Monosodium sulfonate of butyphenol phenol (*Areskep*).
‡ Synthetic commercial liquid sticker and spreader (*Lethane*).
§ Sodium salt of an alkylated naphthalenesulfonate (*Vatsol*).
** Dry gum containing a tapioca base.

the coarse cryolite developed only medium aphid infestations and those dusted with nicotine had practically no aphids. In experiment 1 the aphid infestation was kept down by dusting the 36 plots twice with aphicides, once with 2 per cent nicotine sulfate and once with 1 per cent rotenone. As a result, a 99-to-1 significance between treatments is shown for both boll counts and yield records in this experiment, whereas such a highly significant difference is not shown for these data in the other three experiments.

SUMMARY AND CONCLUSIONS.—Experiments against the boll weevil were conducted at Florence, S. C., in which several insecticides were used both alone and in combination with different commercial wetting agents and stickers. These insecticides consisted of calcium arsenate; two nicotine compounds, one containing nicotine bentonite and the other nicotine bentonite plus nicotine tannate; two cryolite dusts, one a finely ground synthetic cryolite containing 90.8 per cent of sodium fluoaluminate and the other a

coarsely ground cryolite containing 78.3 per cent of sodium fluoaluminate; and a mixture of calcium arsenate and calcium carbonate, which was not combined with a sticker or spreader.

Statistical studies of the data showed that none of the wetting agents and stickers increased the effectiveness of the calcium arsenate or the nicotine compounds. A synthetic liquid sticker and spreader (*Lethane*) increased the effectiveness of the fine cryolite and made it comparable to calcium arsenate. Calcium arsenate, used alone or in combination with stickers and spreaders, and the fine cryolite were superior to the nicotine compounds, with or without stickers and spreaders. The nicotine compounds gave very little, if any, control. No significant difference occurred between calcium arsenate and the calcium arsenate–calcium carbonate mixture. From these studies and from general observations made throughout the season it appears that cryolite might be developed into a satisfactory substitute for calcium arsenate in boll weevil control, provided that its dusting qualities are good and that the percentage of sodium fluoaluminate is high.—4-1-39.

A New Method* of Impregnating Green Fence Posts: A Preliminary Report

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A new method of treating non-durable green pine posts with water-soluble preservatives to make them resist attacks of insects and decays was developed at Clemson College during January, 1938. It is probable that it will be called the trough method of fence post treatment. It is neither complicated nor expensive and its use is expected to supplement materially the present serious shortage of fence post timber.

The idea of injecting water-soluble preservative chemicals into green wood is not new, as the method was widely used in Europe during the past century. Other methods of treating green posts with water-soluble preservatives have been tested by the U. S. Department of Agriculture, Forest Products Laboratory (Hunt & Wirka 1938) and Bureau of Entomology and Plant Quarantine (Craighead *et al.* 1937).

While sufficient time to test the efficiency of the trough method has not elapsed, preliminary observations indicate its merit. This preliminary report is made in the hope that interested investigators will test the method with various species of wood and with other preservatives, because much experimental work is still needed.

HOW TO TREAT.—The following outline is given to show the procedure which was used in treating by the trough method and by which satisfactory impregnation with copper sulfate was secured on several hundred posts. (In some instances zinc chloride, which was used on a few posts, did not appear to give as uniform penetration as copper sulfate.)

Essential Steps.—1. See section on *How to Prepare and Compute the Amount of Solution.* 2. Cut out 6-foot posts of green loblolly, short leaf or slash pine. 3. Immediately immerse top end in trough for 3 hours. 4. Saw off 1-inch disk to remove resinous material from basal end. 5. Place basal end of posts in solution. 6. As soon as solution is absorbed (24 to 48 hours) remove post from trough and reverse ends. 7. Stand up for from 2 to 4 weeks, and preferably until thoroughly seasoned.

Materials and Equipment.—1. Green pine posts, freshly cut. 2. Bluestone or zinc chloride. 3. Trough or half of wooden barrel. 4. Container for stock solution, either wooden, glass, or earthenware if copper sulfate is to be used.

How to Prepare and Compute Amount of Solution.—Dissolve chemical at rate of 2 pounds to each gallon of water. Inject solution into posts at rate of three-quarters pound to each cubic foot of wood. Table 1 will prove helpful in

* E. C. Turner, Jr., extension conservationist, suggested the method and accompanied the writer on a visit to the Forest Experiment Station near Asheville, N. C., where B. H. Wilford of the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, showed one tree treated in similar manner, which gave impetus to development. Raymond Reed of the Physics Department of Clemson College ran some experiments which indicate the merit of the method.

† Extension Entomologist.

Table 1.—Amount to treat 6-foot post, three-fourths pound per cubic foot.

Diameter Inches	Cubic Feet	Approximate Amount Per Post, Pints	Approximate Amount Per Post, Ounces	Cost in Cents at 8 Cents Per Pound
3	0.29	1.0	3.5	2.0
4	0.52	1.75	7.0	3.5
5	0.81	2.5	9.8	5.0
6	1.10	3.5	14.1	7.0

computing amounts for a given lot of posts.

Example.—Assume a trough holding 12 posts of following average diameters: four with 6-inch diameters; four with 5-inch diameters; two with 4-inch diameters; two with 3-inch diameters; table 2 indicates amount of solution required.

Table 2.—Amounts of solution required to treat fence posts of various diameters.

Number of Posts	Average Diameters	Pints Per Post	Total Pints Solution
4	6	3.5	14.0
4	5	2.5	10.0
2	4	1.75	3.5
2	3	1.0	2.0
			29.5

Conclusions.—The trough method of fence post treatment is a new development; however, it seems to offer promise of solving the problem of preserving non-durable woods such as sap pine from insects and decays. Further experimental work on trough method is needed, as follows: 1. preventing possible corrosion to metal fasteners; 2. use of zinc chloride by trough method. However, service tests by the Bureau of Entomology and Plant Quarantine at the Forest Products Laboratory where posts were treated with water-soluble preservatives by other methods indicate a greatly prolonged fence post life. The South Carolina Extension Service is demonstrating the methods of post treatment developed by the foregoing research agencies, and some interested farmers are treating posts by the trough method and placing them in their fence rows for purposes of comparison. Records will be kept on the results of these demonstrations and from time to time additional reports on the length of life of these posts will be made available to South Carolina farmers and to interested scientific workers.—4-1-39.

Literature Cited

Craighead, F. C., R. A. Saint George and B. H. Wilford. 1937. A method for preventing insect injury to material used for posts, poles and rustic construction. U. S. Dept. Ag. Bur. Ent. and Pl. Quar. Multigraph Cir. Ser. E-409. June.

Hunt, George M., and R. M. Wirka. 1938. Tire-tube method of fence post treatment. U. S. Dept. Ag. Forest Products Laboratory. Feb.

The Use of Phenothiazine in the Medication of Cattle for the Control of Horn Flies

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The internal medication of cattle for the purpose of rendering their droppings unsuitable for the development of larvae of the horn fly, *Haematobia irritans* (L.), was first attempted by Gallagher (1928), who made some unsuccessful experiments in 1928. His method was to place various substances in the drinking water of cattle.

Knipling (1938) found that phenothiazine, administered to cattle at the rate of approximately 0.1 gram per kilogram of body weight, prevented the development of horn fly larvae in droppings eliminated by such animals.

Experiments were made in 1938 to determine the value of selected chemicals, including phenothiazine, when administered to cattle *via* the mouth, in preventing the development of horn fly larvae in the droppings and to ascertain

the minimum lethal dose of promising chemicals. This paper deals only with experiments with phenothiazine.

PROCEDURE.—The experimental animals were confined in a screened building where they were fed a ration of bran and hay. After the cattle had been given dry feed for 2 days they were fed phenothiazine mixed with bran. A sample of the droppings was collected within 3 hours prior to medication and at approximately 8-hour and 16-hour intervals after medication for as many days as the test was in progress. The droppings collected before medication served as a check. Approximately 300 grams of the droppings, infested with 50 or 100 horn fly eggs, were placed on 800 grams of moist sand in a pan. The smaller number of eggs was used in most of the tests because the quantity of the droppings from yearling cattle was often insufficient to mature 100 larvae. The droppings from each animal were kept in individual screen cages in the insectary.

RESULTS.—The fact that 96 per cent of all eggs hatched indicates the absence of ovicidal qualities in phenothiazine.

The dose of phenothiazine for the nine animals tested ranged from 5.6 to 100 milligrams per kilogram of body weight (0.25 gram to 4.5 grams per hundredweight). The minimum dose necessary to prevent the development of larvae in the manure was 22 milligrams per kilogram (1 gram per hundredweight). Eight doses of 3 grams each (1 gram per hundredweight) administered at daily intervals to a 300-pound heifer was 100 per cent effective for 8 days beginning about 12 hours after the administration of the first dose and 90 per cent effective on the ninth day, but gave no appreciable control thereafter. Six doses of 2.5 grams each (1 gram per hundredweight) administered at 48-hour intervals to a 250-pound steer was 100 per cent effective the day following medication, but gave practically no control the next day. It is apparent from these two tests that a dose of 22 milligrams per kilogram was effective in preventing the development of horn fly larvae for approximately 24 hours.

Doses in excess of 22 milligrams per kilogram were not only unnecessary to prevent temporarily the development of horn flies in manure, but they caused certain physiological disturbances as manifest in a loss of appetite and the general appearance of the animal. Smaller doses were insufficient to give 100 per cent control. A single dose of 29 grams (4.5 grams per hundredweight) administered to a 650-pound heifer was 100 per cent effective for approximately 55 hours in preventing the development of horn fly larvae in the droppings. In this case 6 per cent of the larvae developed in droppings voided 15 hours after medication and 47 per cent in droppings voided 74 hours after medication. Seven doses of 5 grams each (2.2 grams per hundredweight) administered at daily intervals to a 225-pound steer were effective from 16 hours after the initial dose until 49 hours after the last dose. In two tests with doses of 4.5 grams per hundredweight and two tests with doses of 2.2 grams per hundredweight the animals detected the presence of phenothiazine and did not take readily to the feed. Furthermore, a loss of appetite was evident the day following medication and persisted for 2 days after the last dose. The poor condition of all four animals was indicated by their rough hair, arched back, dull eyes and general haggard appearance.

TREATMENT OF FECES.—To determine the quantity of phenothiazine necessary to render cattle feces toxic to horn fly larvae, when the chemical is mixed directly with the feces, 24 tests were made in which 0.6 milligram to 50 milligrams per 100 grams of feces was used. The method used was to mix 300 grams with an electric mixer for 5 minutes, add the phenothiazine and mix for another 10 minutes. The check samples were similarly mixed for 15 minutes. Each 300-gram sample of feces was infested with 100 horn fly eggs and placed on moist sand in an individual screen cage. The average hatch of eggs in this series of tests was 98 per cent. The minimum lethal dose of phenothiazine was 4 milligrams per 100 grams of feces. Thirteen tests with 4 milligrams or more per 100 grams of feces gave 100 per cent control. Some larvae developed in each sample of feces containing phenothiazine in the amount of 3 milligrams or less per 100 grams.

SUMMARY.—Experiments were conducted to determine the value of pheno-

thiazine in preventing the development of horn fly, *Haematobia irritans* (L.), larvae in cattle droppings. When various quantities of the chemical mixed with bran were fed to cattle, the minimum dose that killed all the horn fly larvae was 22 milligrams per kilogram of body weight of the animal. This dose rendered the manure unfavorable for the development of horn fly larvae for approximately 24 hours, beginning 12 hours after administration. When phenothiazine was mixed directly with the droppings, the minimum lethal dose was 4 milligrams for each 100 grams of the droppings.—4-1-39.

LITERATURE CITED

Gallagher, B. A. 1928. Special report on horn fly experiment. Hawaii. Forester and Ag. 25(3):144–6.
Knipling, E. F. 1938. Internal treatment of animals with phenothiazine to prevent development of horn fly larvae in the manure. JOUR. ECON. ENT. 31(2):315–6. April.

Poisoned-Bait Tests Against the Fire Ant, With Special Reference to Thallium Sulfate and Thallium Acetate*

BERNARD V. TRAVIS, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*

Field experiments (Travis 1938a) have indicated that the fire ant, *Solenopsis geminata* (F.), detects the presence of common insecticides in poisoned baits. Other than the report by Clark (1931) that thallium sulfate was effective for the control of these insects in Texas, and the observations made by Wolcott (1937) on the partial effectiveness of thallium salts for the control of certain species of ants in coffee groves in Porto Rico, the little information available in the literature on the use of stomach poisons (Mallis 1938, Travis 1938b, 1938c) merely points out that poisoned baits are not satisfactory for the control of the fire ant. Cage and field tests were therefore undertaken near Tallahassee, Fla., to ascertain which insecticides could be used, and what concentrations of each would be lethal.

The ants for the cage tests were collected with an aspirator from large active colonies and were placed in plaster formicaries. No more than 3 hours elapsed from the time they were taken from the nests until they were offered poisoned baits. An indication of the acceptability of these baits was obtained by counting the ants feeding on them at 5-minute intervals for the first hour after they were offered.

In the field the baits were placed either in or on the colony mound. Dry materials were sprinkled on the mound, liquids were offered in the ant nests in aluminum poison cups, and in a few tests sirup baits were soaked in sawdust and sprinkled on the mounds. The treated colonies were under observation approximately 3 months after being offered the baits, or until there was no ant activity. These nests were excavated at the completion of the experiment, or previously if the colony became inactive, to determine if the ants had moved or had died. The baits were offered to colonies usually in the spring, although most of the tests with thallous salts were conducted during the summer months.

CAGE TESTS WITH THALLOUS SALTS.—Baits, composed of cane sirup, water and sugar, in a ratio of 1:10:10, were made up with various concentrations (by weight) of thallium sulfate or thallium acetate.† Tartaric acid (0.6 per cent) and sodium benzoate (0.9 per cent) were added as preservatives to many of the baits in both cage and field tests. Two sets of controls accompanied each treatment; one with no food and the other with unpoisoned bait. Each poisoned bait and control was tested in quadruplicate with 25 ants in each formicary. At the end of 48 hours the cages were cleaned and untreated sirup was placed in each. The same controls were used for both salts as they were tested concurrently. Three

* Several of the insecticides were kindly supplied by the Division of Insecticide Investigations of the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture. The ants were determined by M. R. Smith of the Division of Insect Identification of the same Bureau. The managers of Forshala and Horseshoe Plantations, and H. L. Stoddard and E. V. Komarek of the Cooperative Quail Study Association, also cooperated in these studies.

† Thallous sulfate and thallous acetate were used in these tests, but since they are sold commercially as thallium sulfate and thallium acetate, they will be referred to as such in this paper.

replicate tests were run for each concentration, at different seasons.

The temperature for these experiments was maintained at 24±0.5 degrees C. The ants were counted at 48-hour intervals for 288 hours to determine the numbers dead and alive. Individuals that did not move when touched were considered dead and were removed to prevent the other ants from eating them.

Some preliminary tests had been made with thallium compounds along with a number of other insecticides, and for comparative purposes the results of these tests are included with those for miscellaneous insecticides.

Thallium sulfate was tested in seven concentrations ranging from 2.0 to 0.125 per cent. The higher concentrations were dissolved with difficulty in sirup baits. With the 2 per cent solution some of the salt precipitated at 24 degrees C. The mean percentage of ants that fed on these baits was about the same for all concentrations, table 1, and was slightly higher for those to which no preservatives were added, and lower for those with the preservatives, than on the untreated sirup used as a control (see table 2).

The mortality at the end of 288 hours for the ants offered the 2.0, 1.5 and 1.0 per cent baits, both with and without the preservatives was about the same, but the addition of preservatives considerably lowered the results for the baits of lower insecticide content. These tests indicate that the concentration of thallium sulfate would need to be at least 1.0 per cent to

Table 1.—Mortality of fire ants 288 hours after feeding on thallium sulfate baits, with and without a preservative, and percentage of ants that fed during the first hour, 1937–1938.*

Per Cent Insecticide in Bait	Bait Without Preservative		Bait With Preservative	
	Per Cent Dead	Mean Per Cent Feeding First Hour	Per Cent Dead	Mean Per Cent Feeding First Hour
2.00	100.0	24.9	99.0	10.0
	83.0	3.1	86.0	3.3
	88.0	3.1	53.0	0.5
	Av. 90.3	10.4	79.3	4.6
1.50	86.0	9.5	100.0	9.9
	92.0	16.8	75.0	1.9
	72.0	2.8	75.0	0.9
	Av. 83.3	9.7	83.3	4.3
1.00	98.0	15.8	100.0	14.8
	93.0	14.8	50.0	2.2
	68.0	1.6	43.0	1.0
	Av. 86.3	10.7	64.3	6.0
0.75	94.0	18.7	100.0	4.1
	76.0	11.5	42.0	3.1
	55.0	3.3	33.0	2.2
	Av. 75.0	11.2	58.3	3.1
0.50	98.0	24.0	98.0	14.3
	78.0	14.7	15.0	4.7
	60.0	4.8	17.0	1.2
	Av. 78.7	14.5	43.3	6.7
0.25	96.0	24.2	97.0	11.7
	57.0	14.1	3.0	0.8
	25.0	4.0	12.0	0.5
	Av. 59.3	14.1	37.3	4.3
0.125	88.0	24.9	88.0	9.5
	16.0	4.5	1.0	3.9
	7.0	4.1	9.0	0.8
	Av. 37.0	11.2	32.7	4.7

* The data for the controls are given in table 2.

obtain kills of 86 per cent or more when the bait is offered fire ants in cages, fig. 1.

Thallium acetate, which was tested in four concentrations from 4.0 to 0.5 per cent, was readily soluble up to at least 4 per cent in the sirup baits. The ants fed more freely, table 2, on the food poisoned with the acetate salt than on untreated

they were incapable of locomotion for as long as 72 hours previous to death. Thallium salts appeared to affect the leg muscles, and poisoned ants could be seen lying straightened out in the cages with their legs held close to their bodies. When touched they would double up, but usually would not move their appendages. It was common for the ants to die with their

Table 2.—Mortality of fire ants 288 hours after feeding on thallium acetate baits, with and without a preservative, and percentage of ants that fed during the first hour, 1937–1938.

Per Cent Insecticide in Bait	Bait Without Preservative		Bait With Preservative	
	Per Cent Dead	Mean Per Cent Feeding First Hour	Per Cent Dead	Mean Per Cent Feeding First Hour
4.0	100.0	19.3	100.0	16.7
	86.0	6.0	81.0	3.8
	76.0	1.8	82.0	1.5
	87.3	9.0	87.7	7.3
3	100.0	25.1	100.0	5.3
	89.0	8.4	83.0	3.1
	90.0	1.2	92.0	1.1
	Av. 93.0	11.6	91.7	3.2
2	100.0	32.6	77.0	6.8
	99.0	15.8	81.0	3.2
	81.0	3.6	75.0	2.3
	Av. 93.3	17.3	77.7	4.1
1	100.0	13.6	100.0	18.1
	80.0	8.0	55.0	2.7
	64.0	4.1	50.0	2.4
	Av. 81.3	8.6	68.3	7.8
0.5	91.0	18.4		
	40.0	7.4		
	39.0	3.1		
	Av. 56.7	9.6		
Control fed	0.0	5.1		
	1.0	13.8		
	2.0	7.0		
	Av. 1.0	8.6		
Control not fed first 48 hours	20.0			
	1.0			
	4.0			
	Av. 8.3			

sirup. Baits to which the preservatives were added were much less attractive than those without preservatives. These data indicate that a concentration of at least 2 per cent is necessary to produce a mortality of approximately 85 per cent or over in cage tests, table 2 and fig. 2.

Many of the ants became sluggish and many could be seen staggering helplessly around in the cages within 24 hours after feeding on the thallium baits. Frequently

mandibles closed tightly on the wet sponge provided for moisture. These reactions, which were more evident for the acetate than for the sulfate salts, were seldom symptoms of poisoning from other insecticides.

CAGE TESTS WITH MISCELLANEOUS INSECTICIDES.—The tests with miscellaneous insecticides were conducted at air temperatures. Since it was the aim to determine the minimum amount of an

insecticide that would be effective, the poisoned baits usually remained in the cages during the entire experiment. Candies, sirup-agar gels, peanut and olive oils, and corn meal were used as food materials.

Several concentrations of sodium salicylate and sodium fluoride in cane sirup were offered to caged ants for 48, 96 or 288 hours to determine the effectiveness of these different exposures, and the percentages of each group dead at the end of 288 hours were determined. Fresh untreated food was placed in the cages after the first two intervals. The ants fed freely for the first 15 minutes, but after that time few accepted the baits. More fed on the sodium fluoride than on the sodium salicylate baits, table 3. These data indicate that neither sodium salicylate nor sodium fluoride was effective.

The percentages of dead ants in cages supplied with lead arsenate in a cane sirup-agar gel were lower for the 6, 4, 2 and 1 per cent and only slightly higher for the 10 and 8 per cent baits after 192 hours than in the fed controls.

The mortality of ants offered mercurous chloride (6, 4, 2 and 1 per cent) and barium carbonate (8 per cent) in brown sugar sirup candy was only slightly greater after 288 hours than for that of controls receiving food. The candy baits were not practical, because they readily absorbed water, and the ants sucked up the sirup and avoided the insoluble compounds.

Arsenic trioxide, zinc arsenate, manganese arsenate, calcium arsenate (all at concentrations of 15, 10, 5, 2 and 1 per cent), and magnesium arsenate (15, 10, 5 and 1 per cent) were mixed with corn meal moistened with olive oil and cane sirup. The ants fed so freely that their abdomens were distended; yet at the end of 288 hours, except in ants fed the ar-

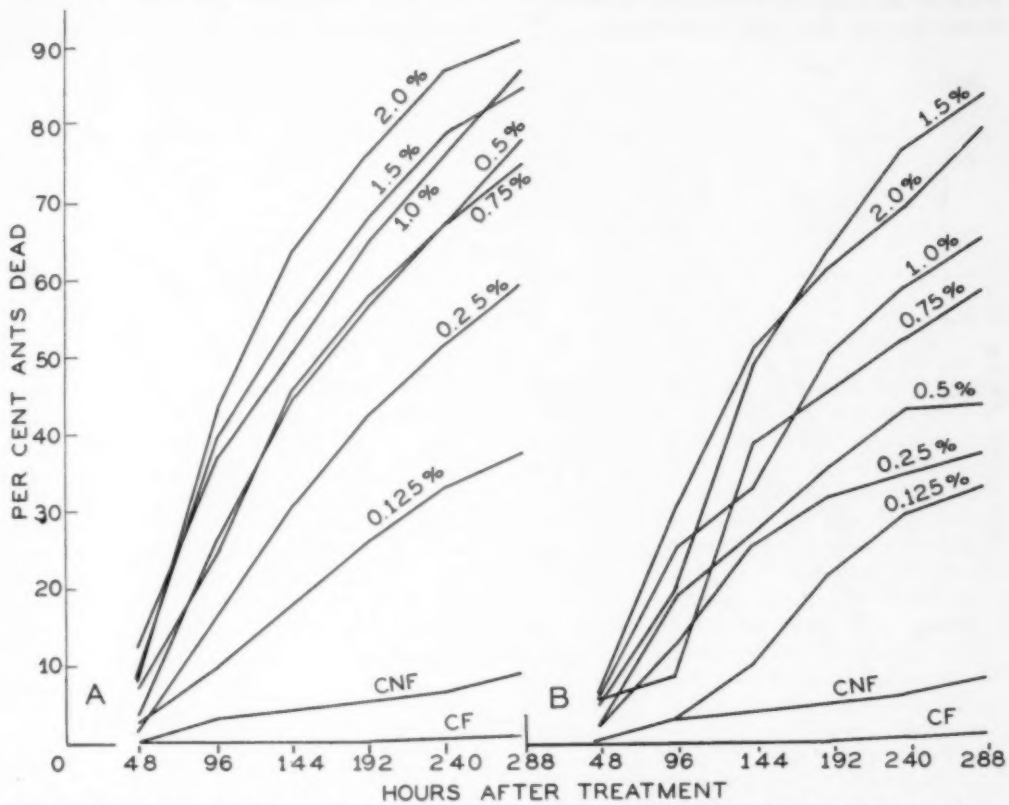

FIG. 1.—Percentages of ants dead at 48-hour intervals after being offered sirup baits containing: *A*, thallium sulfate; *B*, thallium sulfate to which preservatives were added. *CF*, control fed; *CNF*, control not fed first 48 hours. 1937–1938.

senic trioxide baits, the mortality was not significantly greater than in controls receiving food. The mortality in ants fed the arsenic trioxide baits was only slightly more than in the controls that were fed.

The only explanation that can be offered for these low mortalities is that the ants sucked out the sirup and olive oil and did not consume the corn meal with its coating of insecticide. Observations during the cage experiments and also in the field indicate that fire ants seldom, if ever, consume solid foods. This habit has prevented an accurate test of insoluble insecticides.

A number of ants fed on a proprietary sample said to contain 0.37 per cent of thallium sulfate and on a sirup–olive oil emulsion bait with sodium fluoride (3 per cent); only a few fed on the same emulsion with sodium salicylate (3 per cent). Mortality in each case was so low that no toxic effects could be noted.

The ants fed very freely on thallium acetate baits placed in undiluted cane sirup. The mortalities for the ants offered the 2.0, 1.0, 0.5, 0.2 and 0.1 per cent baits at the end of 288 hours were, respectively 92, 29, 18, 22 and 8 per cent, and in the control that was fed the mortality was only 2 per cent.

The ants fed very sparingly on baits containing dioxane (5 per cent), 4,6-dinitro-orthocresol (saturated), and 4,6-dinitro-orthocresol acetate (1.1 per cent) dissolved in refined peanut oil. Since the dinitro compounds were caustic to the skin of the investigator, it is thought that the high mortality with these materials was due to contact action. The percentage of dead ants in the cages supplied with dioxane was less than in the controls.

The following insecticides were not readily accepted in baits: Phenothioxine (5 per cent), phenothiazine (saturated), p-iodonitrobenzene (1 per cent), dibenzo-

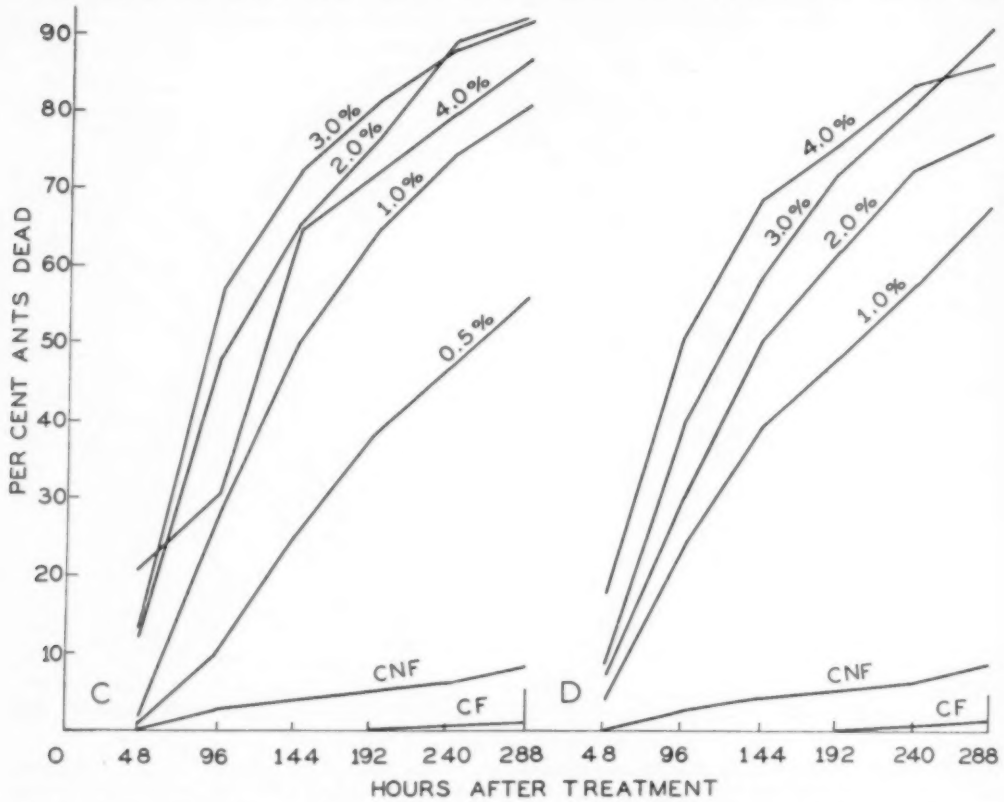

FIG. 2.—Percentage of ants dead at 48-hour intervals after being offered sirup baits containing: *C*, thallium acetate; *D*, thallium acetate to which preservatives were added. *CF*, control fed; *CNF*, control not fed first 48 hours. 1937–1938.

Table 3.—Mortality of ants 288 hours after being offered syrup baits with sodium salicylate or sodium fluoride for 48, 96 or 288 hours, and percentages of ants feeding on these baits during the first hour, 1937.

Concentration of Insecticide in Bait, Per Cent	Percentage of Ants Dead After Exposure			Mean Percentage of Ants Feeding During First Hour When Exposed		
	48 Hours	96 Hours	288 Hours	48 Hours	96 Hours	288 Hours
Sodium Salicylate						
6	66	65	97	3.6	0.4	1.0
4	63	53	73	6.2	2.3	3.7
2	23	37	64	9.1	17.3	22.3
1	17	24	23	11.4	8.6	21.2
Sodium Fluoride						
3	13	37	37	7.7	3.2	7.0
2	26	51	57	16.5	8.7	8.1
1	4	1	20	22.8	19.4	12.4
Controls						
Ants fed	—	—	0	—	—	22.9
Ants not fed	—	—	71	—	—	—

thiophene (5 per cent), dimethyacridan (5 per cent), thiocoumarin (saturated), l-nitrosothiophene (5 per cent), all of which were in refined peanut oil, rotenone (saturated* one-half, one-fifth and one-tenth saturated) which was in crude peanut oil, lead acetate (10, 8, 6, 4, 2 and 1 per cent), thalline sulfate (5, 2 and 1 per cent), chloral hydrate (10, 8, 6, 4, 2 and 1 per cent) and a proprietary bait said to contain 1.25 per cent of thallium sulfate.

The ants fed rather freely on foods to which the following compounds had been added: borax (20, 15, 10, 8, 6, 5, 4, 2 and 1 per cent), Paris green (5, 4, 3, 2 and 1 per cent), sodium fluosilicate (8, 6, 4, 2 and 1 per cent), sodium salicylate (8, 6, 4, 2 and 1 per cent), barium chloride (8, 6, 4, 2 and 1 per cent), sodium arsenite and sodium arsenate† (1.0, 0.5, 0.2 and 0.1 per cent), tartar emetic (saturated, 2.0, 1.5, 1.0, 0.5, 0.2 and 0.1 per cent), a commercial bait said to contain 1.25 per cent of thallium sulfate, and a proprietary bait reputed to contain not over 3.0 per cent of sodium arsenate.

On foods which they accepted the ants fed freely for about the first hour, after which time few were seen to feed.

When results of these miscellaneous tests were compared with the data from the cages where no food was offered, table 4, it became evident that mortality from starvation obscured the effects of the poison, but with few exceptions the highest death rate occurred with the baits containing the largest percentage of the toxic compound. The data so closely parallel the starvation data that it cannot be determined whether the ants died of starvation or from effects of the insecticides. This was shown when 94 per cent of the ants died within 10 days

Table 4.—Mortality of fire ants at 48-hour intervals when confined in plaster formicaries with and without food.

Interval, Hours	Per Cent Mortality	
	With Food	Without Food
48	0.0	0.0
96	1.0	3.0
144	2.0	20.0
192	2.5	88.5
240	3.5	94.0
288	5.5	97.5

* The saturation of crude peanut oil with rotenone in these tests was obtained by placing 1 gram of the latter in 20 grams of the former. The mixture was held at room temperature and stirred daily until it was indicated that a maximum quantity of the rotenone had been dissolved in the oil under these conditions. The supernatant oil was used as the saturated bait after the mixture had been allowed to settle following the last stirring. Various degrees of saturation were obtained by dilution of the saturated oil.

† The sodium arsenite and the sodium arsenate used in these tests were obtained from local drug stores and their exact chemical analysis is unknown. It is probable that the former was the meta-arsenite and that the latter was either $Na_2HAsO_4 \cdot 12H_2O$ or $Na_2HAsO_4 \cdot 7H_2O$. Since the tests with these compounds were negative, it was not considered necessary to determine their exact chemical composition.

when confined in cages without food. There was also the added difficulty that moisture was lost when the baits were left in the cages for the 288-hour period, thus producing a large error in the concentrations of the insecticides. In spite of these two factors only rarely was the mortality of ants that were offered the poisoned foods higher than that of ants offered no food.

no dead ants were noted near the mounds.

Thallium acetate was tested in the same concentrations used in the cage tests, both with and without preservatives. A sirup bait of each concentration was soaked in sawdust and sprinkled on the ant nests. All the colonies were destroyed. The results obtained in later tests of this type were erratic, for few ants fed during dry weather but good

Table 5.—Percentage of colonies inactive after being offered sirup baits containing various concentrations of thallium acetate and thallium sulfate in bait cans, 1938.

Concentration of Insecticide, Per Cent	No Preservative Added		Preservative Added	
	Total Number of Colonies	Per Cent of Colonies Inactive	Total Number of Colonies	Per Cent of Colonies Inactive
Thallium Acetate				
4.0	5	100.0	2	50.0
3.0	3	100.0	4	50.0
2.0	3	100.0	4	75.0
1.0	4	75.0	4	25.0
0.5	4	0.0	2	50.0
Thallium Sulfate				
2.0	3	66.7	2	0.0
1.5	4	20.0	3	33.3
1.0	3	0.0	3	0.0
0.75	4	25.0	3	66.7
0.5	1	0.0	2	0.0
0.25	2	0.0	3	0.0
0.125	1	0.0	3	0.0

FIELD TESTS WITH THALLOUS SALTS.—Tests in the field with the thallium sulfate and thallium acetate, which appeared so effective in cage experiments, included only a small series of colonies because the project was discontinued before it was completed. Thallium sulfate, both with and without preservatives, was tested in the same concentrations used in the cage tests. Three of four colonies were destroyed in one experiment in which the bait (1.5 per cent) was soaked in sawdust and sprinkled on the colony mound. These colonies were in the shade of trees during the first few hours after the poisoned food was applied, and rain the previous day had soaked the ground thoroughly.

Thallium sulfate in sirup baits did not prove effective even when applied in aluminum containers, table 5. The ants did not feed freely and frequently moved from the mound in which the can was placed. In one experiment where seven colonies were offered thallium sulfate (1.5 per cent) in 3 parts of sirup and 1 part of crushed sardines, all remained active and

feeding occurred when the soil was moist to the surface, *i.e.*, following rains.

Satisfactory results were obtained with 4, 3 and 2 per cent baits to which no preservatives had been added when offered in aluminum cans. The addition of sodium benzoate and tartaric acid decreased the effectiveness of the bait, table 5. Frequently the higher concentrations of the acetate seemed to be more attractive than the lower.

Three colonies offered a 2 per cent thallium acetate bait with 3 parts of sirup and 1 part of crushed sardines all remained active.

The ants died in the nest when poisoned with thallium acetate, and seldom were piles of dead seen around the mound as is the case when killed with other insecticides. The shortest period in which a colony was completely destroyed was 5 days, and the longest nearly 3 months. Sick ants could be seen staggering around the mounds for several days after the treated food was offered. When a mound was disturbed, the ants that came out were sluggish and did not have good walk-

ing coordination. These observations correspond with those obtained in the cage tests.

FIELD TESTS WITH MISCELLANEOUS INSECTICIDES.—The following insecticides were tested against the fire ant in the field: Sodium arsenite (1.0, 0.5, 0.3, 0.25, 0.2, 0.15 and 0.025 per cent), sodium arsenate (1.0, 0.5, 0.3, 0.2, 0.15 and 0.1 per cent), lead arsenate (5, 4, 2 and 1 per cent), zinc arsenate (2 per cent), manganese arsenate (2 per cent), magnesium arsenate (2 per cent), thalline sulfate (1.0, 0.5 and 0.4 per cent), lead acetate (4, 2 and 1 per cent), mercurous chloride (4 and 2 per cent), tartar emetic (4 and 2 per cent), rotenone (1.5, 0.2 and 0.1 per cent), cuprous cyanide (1 per cent), phenothiazine (1.0, 0.4, 0.2 and 0.02 per cent), cryolite (2 per cent), sodium fluoride (5.0, 2.0, 0.6, 0.5, 0.3 and 0.15 per cent), sodium fluosilicate (2 per cent), sodium salicylate (6, 4, 2 and 1 per cent), borax (20, 15, 10 and 5 per cent, 4, 6-dinitro-orthocresol (saturated), 4, 6-dinitro-orthocresol acetate (1.1 per cent), and three proprietary samples, two of which were said to contain 1.25 per cent and one 0.37 per cent of thallium sulfate.

These compounds were added to the following materials known to be attractive to fire ants: Cottonseed oil, peanut oil, olive oil, cane sirup, cane sirup–agar gel, honey, brown sugar, canned mackerel, canned liver, canned corned beef, canned sardines, canned milk, dried milk, cottonseed meal, peanut meal, rolled oats, bran mash, dried egg yolk, dried whole egg and dwarf millet seed.

None of these materials gave indication of being of value in the control of the fire ant. The ants fed a few minutes on most of these baits, and then covered them with soil and abandoned them. Dry baits were taken into the mound and usually carried out again after an hour to several days. In a few cases when dry baits were offered in aluminum cups the ants removed the contents and used the containers for brood chambers.

OBSERVATIONS ON MISCELLANEOUS OTHER ANTS.—Other species of ants, particularly *Dorymyrmex pyramicus* var. *flavus* MacCook, *D. pyramicus* var. *niger* Pergande, *Iridomyrmex pruinosus* (Roger) *Pheidole metallescens* Emery, *Crematogaster victima* subsp. *missouriensis* Pergande, and *Camponotus abdominalis* subsp. *floridanus* (Buckley), would feed on many of the poisoned foods even when not accepted by fire ants. This was particularly true for the sodium arsenite, sodium arsenate, tartar emetic, phenothiazine, rotenone and thallium baits.

SUMMARY.—A large number of insecticides, particularly thallium sulfate and thallium acetate, which are commonly used as poisons for other species of ants, were tested in baits both in cages and in the field, to determine their effectiveness against the fire ant, *Solenopsis geminata* (F.).

Thallium sulfate in concentrations of 1.0, 1.5 and 2.0 per cent was toxic in cage tests but not in the field. Thallium acetate in concentrations of 2, 3 and 4 per cent was very effective in both cage and field tests. The addition of sodium benzoate and tartaric acid to the baits appeared to repel the ants. No satisfactory results against fire ants were obtained, either in cages or in the field, with any of the other insecticides. The habit of the fire ant to suck juices out of baits and avoid solid materials prevented a thorough study of the insoluble insecticides. Contrary to expectation, 94 per cent of the fire ants starved within 10 days when confined in cages without food.—3-20-39.

LITERATURE CITED

Clark, S. W. 1931. The control of fire ants in the lower Rio Grande Valley. Tex. Ag. Exp. Sta. Bul. 435. 12 pp., illus.

Mallis, Arnold. 1938. The California fire ant and its control. Pan-Pacific Ent. **14**: 87–91.

Travis, Bernard V. 1938a. The fire ant (Solenopsis spp.) as a pest of quail. JOUR. ECON. ENT. **31**: 649–652.

Travis, Bernard V. 1938b. Fire ant problem in the Southeast with special reference to quail. Third N. Am. Wildlife Conf. Trans., pp. 705–8.

Travis, Bernard V. 1938c. Fire ant investigations. Cooperative Quail Study Assn., Thomasville, Ga. Sixth Ann. Rep. **1936–37**: 22–25.

Wolcott, George N. 1937. Annual report for the fiscal year 1934–1935. Division of Entomology. Puerto Rico Ag. Exp. Sta. Rep. 1934–35, pp. 41–9.

Ease of Residue Removal From Late and Early Spray Applications of Lead Arsenate to Apples

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In an effort to minimize the problem of removal of spray residues resulting from lead arsenate sprays, recommendations for commercial orchards suggest a reduction in the number of late spray applications. Such recommendations are based on the inference that, because of its greater quantity, the residue from late spray applications is more difficult to remove than that from sprays applied early in the season. It is the purpose of this paper to show the effect of time of spray application and of different spray materials on the residue load at harvest and the ease of residue removal.

METHODS OF ANALYSIS.—The data reported are based on 50-fruit samples analyzed in 25-fruit duplicates by the electrolytic-dithizone method (Association of Official Agricultural Chemists, 1935) for determination of lead residues in fresh fruit. Smith & Cassil (1937) have shown, by statistical studies of the analysis of individual fruits from a single tree, that differences of 10 per cent of the common mean between two samples would be significant at odds of 19 to 1 if 70 fruits were used in each sample. The authors have found the same variation of residue load on fruit from a five-tree plot, in which all trees were represented. From these results it can be assumed that differences of 12 per cent of the common mean would be significant at odds of 19 to 1 when 50-fruit samples were employed.

WASHING PROCEDURE.—The fruit was washed with hydrochloric acid solutions in an under-brush machine under the conditions given in table 1.

Table 1.—Exposure time, concentration of acid and temperature of hydrochloric acid solutions used in washing apples.

YEAR	EXPOSURE, SECONDS	CONCENTRATION OF ACID, PER CENT BY WEIGHT	TEMPERATURE, DEGREES F.
1935	30	1.1	100
1936	20	1.5	100
1937	30	1.4	92

Since alkaline washes have proved unsatisfactory for removal of spray residues containing Bordeaux mixture, they are not considered applicable to midwestern conditions and were not used in these experiments.

EXPERIMENTS IN 1935.—During the 1935 growing season three plots of Grimes Golden apple trees receiving lead arsenate sprays were included in the experimental orchard near Vincennes, Ind. Because of the heavy residue loads found following sprays applied July 18, it was decided to reduce the spray load at harvest by discontinuing spraying some of the trees of each plot. Each plot was therefore divided into two plots. These two plots received identical spray treatments until July 18; thereafter one plot of each pair received two additional sprays of the same material and the other plot was not sprayed again. At harvest fruit was taken from each of the six plots for study of spray residue removal.

The data in table 2 show that the plots (1, 2, 3) that received two sprays after July 18 carried double the residue found on plots that were not sprayed after that date.

Since each pair of plots, 1 and 1A, 2 and 2A, and 3 and 3A received identical sprays except for the last two applications, it might be assumed that the residue on fruit from plots 1A, 2A and 3A would be much more easily removed than that from plots 1, 2 and 3. The results after washing show no significant difference in the residue loads on fruit from plots 1 and 1A or 3 and 3A, although there is a significant difference (at odds of 19 to 1) in the loads on fruit from plots 2 and 2A. In view of all these data it is probable that reducing the harvest residue load by eliminating final spray applications does not materially lessen the problem of residue removal.

EXPERIMENTS IN 1936.—In 1936 experiments were designed to measure the harvest residue load and the ease of residue removal from first- and second-brood spray applications. Lead arsenate was used alone and in combination with Bor-

deaux mixture in standard spray schedules and with organic insecticides. Seven plots of Jonathan apple trees were treated.

The residue loads before and after washing are given in table 2. In plots 4 and 5 lead arsenate was used in all spray treatments. Plot 5 received two more first-brood sprays than plot 4; otherwise the treatments were identical. The residue load at harvest on fruit from plot 4 was nearly 10 per cent lower than on fruit from plot 5; however, practically no difference is shown in the residue loads after washing. Plots 5 and 6 received identical spray treatment in the first-brood period and differed only during the second-brood period, when plot 5 received four sprays and plot 6 was left unsprayed. The harvest residue load on fruit from plot 5 was nearly three times that from plot 6. After washing, the residue on the fruit from plot 5 was significantly greater (at odds of 19 to 1) than that from plot 6; but the difference was by no means so great as on unwashed fruit.

Plots 4, 7 and 8 offer another comparison between a full lead arsenate spray schedule and first-brood sprays of lead arsenate. In plot 7 nicotine sulfate with oil was used after four applications of lead arsenate, and in plot 8 nicotine peat without an adhesive was used in four applications. The fruit in plots 7 and 8 carried a much smaller harvest residue than that in plot 4. After being washed, the fruit in plot 7 carried a significantly greater residue than that in plot 4 (at odds of more than 19 to 1). In this case the oil of the nicotine-oil spray hindered

Table 2.—Results of spray residue removal studies, 1935, 1936 and 1937.

Year and Plot No.	Treatment	Number of Sprays		Residue Load, Grain Lead Per Pound	
		First-Brood	Second-Brood	Unwashed	Washed
1935					
1	Lead arsenate–Bordeaux	4	3	0.200	0.013
1A	Same as plot 1	4	1	0.103	0.014
2	Lead arsenate–lime–mineral oil, final sprays of lead arsenate–Bordeaux	5	3	0.364	0.033
2A	Same as first six sprays for plot 2	5	1	0.149	0.024
3	Lead arsenate–lime–mineral oil–soap, four sprays followed by lead arsenate–Bordeaux	6	3	0.344	0.022
3A	Same as plot 3	6	1	0.174	0.021
1936					
4	Lead arsenate–Bordeaux	4	4	0.179	0.018
5	Lead arsenate–Bordeaux	6	4	0.198	0.019
6	Lead arsenate–Bordeaux	6	0	0.071	0.016
7	Lead arsenate–Bordeaux, first-brood; nicotine–mineral oil, second-brood	4	4	0.055	0.023
8	Lead arsenate–Bordeaux, first-brood; nicotine peat, second-brood (no adhesive)	4	4	0.049	0.012
9	Nicotine bentonite–soybean oil, first-brood; lead arsenate–Bordeaux, second-brood	4	4	0.177	0.009
10	Phenothiazine, 7 sprays; lead arsenate–Bordeaux, final spray	4	4	0.061	0.004
1937					
11	Lead arsenate–Bordeaux	4	3	0.159	0.017
12	Lead arsenate–Bordeaux, mineral oil included in two first-brood sprays	5	3	0.210	0.024
13	Lead arsenate–Bordeaux, mineral oil included in two first-brood sprays followed by nicotine bentonite–soybean oil in second-brood sprays	5	3	0.095	0.023
14	Nicotine bentonite–soybean oil, first-brood; lead arsenate–Bordeaux, second-brood; soybean oil in first second-brood spray	4	3	0.141	0.013
15	Phenothiazine, first-brood; lead arsenate–Bordeaux, second-brood; soybean flour in first second-brood spray	4	3	0.095	0.012

the removal of the residue. The fruit in plot 8, on the other hand, was significantly cleaner than that in plot 7. The nonadhesive character of the nicotine-peat spray mixture made this possible.

In plots 4 and 9 we have a comparison between a full lead arsenate spray schedule and four second-brood sprays of lead arsenate. The difference in the harvest residue loads is probably nonsignificant, but after washing there is a decided difference in the residue loads, showing that second-brood sprays are easily removed regardless of the harvest residue load.

A direct comparison between first- and second-brood lead arsenate sprays can be obtained from the data of plots 7 and 8 and plot 9. Plots 7 and 9 are opposite in regard to spray schedules. In plot 7 nicotine and mineral oil followed lead arsenate, whereas in plot 9 lead arsenate followed nicotine bentonite and soybean oil. The residue load at harvest on plot 7 was less than one-third that on plot 9, but, after being washed, the fruit from plot 7 carried more than twice the residue load of the fruit from plot 9. Here again the oil adhesive on top of lead arsenate probably complicated removal. The fruit from plot 8, which received no adhesive in its spray schedule, carried less than one-third the harvest residue load of plot 9, and after washing the difference was significant at odds of 19 to 1. Thus, although four second-brood sprays may give a much greater harvest residue than four first-brood sprays, that residue can be reduced to meet a tolerance as easily as that from the four first-brood sprays.

A further comparison was made between plot 8, which received four first-brood sprays of lead arsenate and plot 10, which was given only one final lead arsenate spray. The harvest residue from the final lead arsenate spray was greater than that from four first-brood sprays. After washing, the residue from a final lead arsenate spray was reduced to 0.004 grain of lead per pound, whereas the residue from four first-brood sprays was 0.012 grain of lead per pound.

EXPERIMENTS IN 1937.—Five plots of Jonathan apple trees were treated in 1937. In general the same relationships are shown by the 1937 data as by the 1936 data. On comparing plot 11 with plot 14 it is shown that second-brood sprays may deposit nearly as great a residue as a full schedule of lead arsenate but that the residues are more easily removed. In plot 13 lead arsenate in first-brood sprays is followed by nicotine bentonite, and in plot 14 the opposite schedule exists. The residue loads in the two plots show the same general relationship as those in similar plots (7 and 9) in 1936. A comparison of plot 13, which received lead arsenate in first-brood sprays, with plot 15, which received lead arsenate in second-brood sprays, shows these two plots to carry identical harvest residue loads. After washing, the residue from second-brood lead arsenate sprays was reduced to 0.012 grain of lead per pound; the residue from first-brood sprays was 0.023 grain of lead per pound.

The only new comparison in the 1937 data is found in plots 11 and 12. These plots differ principally in the inclusion of mineral oil adhesive with lead arsenate in two first-brood sprays in plot 12. The effect of this adhesive is measurable both in the harvest residue and in the residue after washing.

SUMMARY.—Experiments were undertaken in southern Indiana during 1935, 1936 and 1937 to determine the relative ease of removal of residues on fruit resulting from early and late applications of lead arsenate sprays. Spray schedules designed to permit such a comparison were applied in experimental apple orchards near Vincennes, Ind. Samples of fruit from the spray plots were washed with hydrochloric acid solutions, and analyses were made for lead residues before and after washing.

The residue load at harvest from a given number of lead arsenate sprays increases as the time of spray application approaches harvest time; thus, a final cover spray of lead arsenate may leave, at harvest, a residue load equal to that resulting from four first-brood sprays. The residues from sprays applied in the second-brood period are more easily removed by washing than are residues from the same number of the same sprays applied during the first-brood period. The use of oil adhesives with organic insecticides, in second-brood sprays, makes the residue of lead arsenate from first-brood sprays as difficult to remove as are residues from lead arsenate used throughout the season.—1-27-39.

LITERATURE CITED

Association of Official Agricultural Chemists. 1935. Methods of analysis: 375–93.
Smith, C. M., and C. C. Cassil. 1937. A statistical study of the sampling and analytical errors encountered in analyzing apples for lead spray residues. Jour. Assn. Official Ag. Chem. **20**: 617–22.

Biology and Habits of *Ephialtes turionellae* (L.),* a Pupal Parasite of the European Pine Shoot Moth

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Ephialtes turionellae (L.) is an important pupal parasite of the European pine shoot moth, *Rhyacionia buoliana* (Schiff.), in Europe. It was first imported in 1906, under the name *Pimpla examinator* F., for liberation as a parasite of the gypsy moth, but failed to become established (Howard & Fiske 1911). It was imported and released in pine shoot moth infestations in 1933, 1934 and 1935. During this three-year period 699 parasitized host pupae were received in this country and 160 of these produced adult parasites. The adult parasites, however, did not issue until after the pupae of *R. buoliana* had produced moths. Since very few *E. turionellae* adults were received during any one season and they issued too late to be effective as parasites of the pine shoot moth pupae, consideration was given to rearing the parasite on an alternate host and liberating it in greater numbers at a time when *R. buoliana* pupae were abundant in the field. Thorpe (1930) has published a host list indicating the polyphagous habits of this parasite. In order to find a suitable host for mass production in the laboratory, pupae of several species of Lepidoptera were exposed to gravid females for attack. It was found that *E. turionellae* could be reared with varying degrees of success on a number of species of lepidopterous pupae that occur in New England. *Cacoecia cerasivorana* (Fitch) proved to be the most satisfactory host for large-scale rearing of the parasite. Although Meyer (1925) has given a good account of the biology and morphology of *E. turionellae*, further observations made on the life history and habits of this species during the course of the rearing work in the United States are included in this paper.

REARING.—Preliminary experiments in rearing *Ephialtes turionellae* were begun in 1934. The first hosts exposed to attack by the parasite were *Pieris rapae* (L.) and *Autographa brassicae* (Riley). Both these species were attacked readily when exposed in webs or wrapped in absorbent cotton. *Pyrausta nubilalis* (Hbn.) is also a very satisfactory host, particularly for use in building up a stock of parasites in the winter. Several other solitary hosts were tried with varying results, but, as has been stated, the gregarious tortricid *Cacoecia cerasivorana* (Fitch) was the most satisfactory for mass production of the parasite.

Cacoecia cerasivorana is a lepidopterous insect known as the ugly-nest caterpillar. It feeds on wild cherry. The larvae spin webs inclosing the foliage, and practically all feeding takes place within the nest. After feeding is completed, the larvae migrate to the center of the web, where they spin cocoons. The cocoons, together with the frass, form a compact mass which contains from 100 to 1,000 pupae.

The caterpillar pupae were exposed to attack by *Ephialtes* in lots of 100 to 200. The outer webbing was removed and the larger nests were broken into smaller sections so that most of the pupal cases were exposed. This method has proved very satisfactory in producing a high percentage of parasitized pupae.

A limited amount of time has been available for rearing *Ephialtes turionellae* so that only a small supply of overwintering females has been retained for propagation work. The results, however, have been very satisfactory, and sufficient numbers of parasites have been obtained for colonization in most of the areas infested by the European pine shoot moth.

In 1935, 40 hibernating *Ephialtes turionellae* females were retained for rearing purposes, from which a progeny of 1,453 adults were obtained. In 1936, only

* Order Hymenoptera, family Ichneumonidae.

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25 overwintering females were kept for propagation of the species. A first and partial second generation of parasites reared on *Cacoecia cerasivorana* yielded a total of 4,145 *E. turionellae* adults in 1936. Production on a somewhat larger scale was begun in 1937. About 250 female parasites were available in the spring and two generations were reared on *C. cerasivorana*. These rearings resulted in 13,716 females of *E. turionellae*.

HOST RELATIONS.—*Ephialtes turionellae* is diverse in its feeding habits and is known to attack a number of lepidopterous hosts in Europe. Thorpe (1930) gives a host list of 39 species, representing 15 families. Meyer (1925) states that it is one of the most polyphagous parasites of the family Ichneumonidae. He has recorded 20 hosts, including 5 not mentioned by Thorpe.

In the United States *Ephialtes turionellae* has been reared in the laboratory from the hosts listed below. Lepidoptera: *Cacoecia cerasivorana* (Fitch), *Pyrausta nubilalis* (Hbn.), *Malacosoma americana* (F.), *Pieris rapae* (L.), *Autographa brassicae* (Riley), *M. disstria* Hbn., *Notolophus antiqua* (L.), *Alypia octomaculata* (F.), *Dioryctria zimmermanni* (Grote), *Anisota senatoria* (A. & S.) and *Cacoecia fervidana* (Clem.); Hymenoptera: *Dioctes punctoria* Roh., a primary parasite of *P. nubilalis;* Diptera: *Ernestia ampelus* (Walk.), a primary parasite of *M. disstria*. Some of these hosts may not be subject to attack by *E. turionellae* in the field, but there are, without doubt, many other species that would serve as hosts for this parasite.

HIBERNATION.—Thorpe (1930) indicates that *Ephialtes turionellae* in its natural environment passes the winter in the immature stages within the body of its host pupa. The development of half- to full-grown larvae has been retarded for 30 to 60 days at 32 to 38 degrees F. in the laboratory, but no attempts have been made to carry the immature stages through the winter in the United States. These larvae developed normally when subjected to higher temperatures and no ill effects were apparent. In an unheated insectary in Massachusetts hosts attacked as late as October produced adults. The life cycle was longer by several days than in the field, some individuals developing into adults on warm days in December. Females have hibernated successfully at normal winter temperatures in Massachusetts. During the severe winter of 1934–35 there was a mortality of only 10 per cent when the parasites were held in wooden boxes in an unheated insectary where the temperature dropped to −11 degrees F. A few of the late-emerging males have always survived the winter. In the laboratory very low mortality of this species has occurred during the winter at temperatures ranging from 32 to 38 degrees F. At these temperatures the parasites have usually been supplied with cube sugar and water, as a precautionary measure, although no feeding has been observed. The data strongly indicate that *E. turionellae* will survive the winters in most parts of the United States.

MATING.—Mating occurs readily at any temperature at which the parasites are active. Those emerging in the fall mated at 50 degrees F. The males may continue to mate during their entire life. The females will mate a number of times during the first day or two after emerging, but fertilized females will not mate after they are older. Females that have not been fertilized will mate after they are several months old, but they also will refuse males a day or two after the first union. Mating lasts from 30 seconds to 5 minutes.

OVIPOSITION.—Females of *Ephialtes turionellae* reared at temperatures of 80 degrees F. or more begin ovipositing soon after emerging. Those females developing at lower temperatures, 50 to 65 degrees F., do not oviposit for a week or two after becoming adults. If reared at high temperatures, then cooled to 40 degrees F. for a period of a week, they will not oviposit until 4 to 7 days after being subjected to temperatures of 70 to 80 degrees F. Adults developing in October would not oviposit the following spring until they had been subjected to temperatures of 50 to 75 degrees F. for a period of 2 weeks.

DEVELOPMENT.—The egg is deposited in the host pupa and may be found in nearly any part of the body. Hatching occurs within 2 to 4 days at summer temperatures.

The larvae feed within the host during all stages. They develop rapidly and attain full growth in from 6 to 10 days.

The naked parasite pupa is formed

within the walls of the host pupa and develops into an adult within 6 to 10 days. The newly emerged adult then cuts a hole in the wall of the host pupa and comes out.

The time required for development from egg to adult is 14 to 20 days at temperatures of 80 degrees F., but at ordinary summer temperatures 20 to 25 days are required for a generation. At prevailing temperatures in New England six complete generations were reared in 1935. This necessitated a constant supply of host material from the time the parasite became active in the spring until it went into hibernation in the fall.

HOST RESISTANCE.—*Ephialtes turionellae* seems to be physiologically adapted to reproduce on a variety of hosts. Of the many hosts exposed in the United States, *Notolophus antiqua* was the only species which showed a decided resistance to the development of eggs and young larvae of this parasite. One lot of 50 *N. antiqua* pupae that had been attacked failed to produce a single parasite. Dissections of the host pupae showed that none of the parasites had developed beyond the early larval stages. Another lot of 300 pupae were parasitized. Dissections of 200 of these pupae within 10 days after attack revealed 100 containing dead parasite eggs, 60 with dead first-stage larvae, 3 with living larvae that were almost full grown and 37 showing no signs of attack. The 100 pupae that were retained produced 50 moths and 1 adult *E. turionellae.*

The dead eggs and the larvae were surrounded by a transparent wall of a gelatinous material. This condition is probably what has been referred to as phagocytosis by Muesebeck & Parker (1933), in which eggs and larvae of *Hyposoter disparis* Viereck failed to develop in *Porthetria dispar* (L.).

FEEDING HABITS.—The adults fed greedily on the lump sugar and honey water solution supplied them. The males confine their feeding to this diet, but the females commonly feed on the juices of the host pupae. This food is obtained by inserting the ovipositor into the pupa, twisting it around and then feeding on the exuding juices. Often the feeding is accomplished without the ovipositor being completely removed from the puncture hole. This feeding habit of the female is rather common in this group and was mentioned by Cushman (1913) in his work on the *Calliephialtes* parasite of the codling moth.

In confinement many of the parasitized, as well as the unparasitized host pupae are killed by this feeding habit. This same condition apparently exists in the field and may explain the low percentage of emergence of parasites from *Rhyacionia buoliana* pupae received from Europe. The pupae that have been killed by the feeding of the parasite have the same general appearance as those containing living parasite pupae. They can often be distinguished, however, upon examination in a strong light, and if bounced on a hard surface the unparasitized pupae usually bounce higher.

REPRODUCTIVE CAPACITY.—Some data regarding the reproductive capacity of *Ephialtes turionellae* were obtained in connection with the propagation of this species. No attempts were made, however, to obtain records on individual females. Meyer (1925) states that the reproductive capacity of this species is not great. He gives the records of two females, one of which deposited 46 and the other 51 eggs. In 1935 one cage of 40 *E. turionellae* females produced 1,453 adults, an average of 36 per female. In 1936 one cage of 25 females produced 1,381 adults, an average of 55 per female. These figures do not represent a true measure of the biotic potential, but they show the actual increases that can be expected in practical rearing of the species in the laboratory. In these experiments there was a loss of eggs due to multiple parasitism, as was shown by dissections of samples of the parasitized pupae. There was also a loss of eggs due to the adult parasites' feeding on the parasitized pupae and killing them before the parasite larvae developed.

PROPORTION OF SEXES.—According to Thorpe (1930) males and females appeared in approximately equal numbers in Great Britain. Morley (1908, p. 99) on the other hand concludes that females must be very rare in Great Britain. In the material received from Austria the proportion of males to females was about 1:2. Data obtained from the rearing work in the United States indicate that the ratio of males to females is affected by the size and succession of hosts. Adult parasites reared from large hosts have always

produced a higher ratio of males when they were allowed to reproduce on a smaller host. Parasites reared from small hosts have always produced a higher percentage of females when allowed to reproduce on a larger host. In the experiments mentioned above, the ratio of males to females ranged from 2:1 to 1:3 in the most extreme cases. When successive generations were reared on the same host, the ratio of males to females averaged 4:5. Fertility appeared to decrease as the females became older, as there has always been a preponderance of males, about 3:1, in the generations reared from overwintering females that were mated before they hibernated.

HYPERPARASITIC HABITS.—Under laboratory conditions *Ephialtes turionellae* has been reared on one hymenopterous host, *Dioctes punctoria* Roman, and on one dipterous host, *Exorista ampelus* (Walk.). In both cases these hosts were wrapped in cotton to facilitate oviposition. Occasionally this species may occur as a secondary parasite but its role as such is probably accidental and so rare as to occasion no alarm. It has not been recorded as a secondary parasite from field-reared material.

COLONIZATION.—Liberations during the period 1935–37 totaled 1,732 males and 10,744 mated females. Five thousand seven hundred thirty mated females were colonized in European pine shoot moth infestations. Several of these colonies consisted of overwintering females that were released in the spring when *Rhyacionia buoliana* pupae were in the field. Most of the colonies, however, were released in the summer after the issuance of the pine shoot moth adults. It was hoped that they would propagate on other lepidopterous hosts or survive until the following spring and attack the developing pupae of *R. buoliana*. Colonies were released at Branford, Fairfield, Newtown and Meriden in Connecticut; Lewiston, Niagara Falls, Buffalo, Syosset and North Castle in New York; and New Vernon and Boonton in New Jersey. Two colonies were sent to Ontario, Can., and were released there by officers of the parasite laboratory of the Canadian Department of Agriculture. In addition to liberations in European pine shoot moth infestations, one colony of 3,000 mated females was released in an infestation of *Malacosoma disstria* at Cass Lake, Minn., and one colony of 2,000 mated females in an infestation of *Hemerocampa pseudotsugata* McD. in the Saw Tooth National Forest at Shoshone, Idaho.

Although this parasite has not yet been recovered from the field in America, the fact that it will successfully attack a rather wide range of hosts in the laboratory is an indication that its chances of establishment are good, and it is hoped that it may prove eventually to be of some importance as a parasite of forest insects in this country.

SUMMARY.—*Ephialtes turionellae* (L.) is an important pupal parasite of the European pine shoot moth, *Rhyacionia buoliana* (Schiff.), in Europe.

It was first introduced into the United States as a parasite of the gypsy moth, but failed to become established. The second attempt to colonize this parasite was for the control of the European pine shoot moth. Importations were begun in 1933 and continued through 1935. Numerous colonies were liberated but no recoveries have been made as yet under field conditions.

In view of the difficulties attendant upon obtaining sufficient numbers from Europe for liberation, methods for rearing this parasite in the United States were developed. Investigations have shown that large numbers may be successfully reared in the laboratory with little effort.

This parasite has a number of lepidopterous hosts in Europe and it will reproduce successfully under laboratory conditions on a number of species native to the United States.

Twenty-five females produced 1,381 progeny, an average of about 55 each. The biotic potential is somewhat higher, as many of the parasite eggs were destroyed by the adults' feeding on the parasitized pupae. The life cycle is completed in 14 to 25 days and six or more generations a year can be produced at prevailing temperatures in New England. The species overwinters as an adult and possibly also in the immature stages at times and is apparently little affected by low temperatures.

One host, *Notolophus antiqua*, showed a decided resistance to the development of eggs and young larvae of *Ephialtes turionellae*. A reaction known as phagocytosis occurred and the eggs and larvae

were encysted in a gelatinous mass. This host is therefore practically immune to the parasite.

Ephialtes turionellae females kill many of their host pupae by feeding on the body fluids. This act is accomplished by inserting the ovipositor, twisting it around vigorously and then feeding on the body fluids as they exude.

Data obtained from laboratory rearing work in the United States indicate that the ratio of males to females is affected by the size and succession of hosts. Adult parasites reared from large hosts have always produced a higher ratio of males when they were allowed to reproduce on a smaller host. Parasites reared from small hosts have always produced a higher percentage of females when allowed to reproduce on a larger host. When the successive generations were reared on the same host there were slightly more females than males. Mated females appeared to lose fertility as they grew older, as was evidenced by a higher percentage of males reared from overwintering females.

Under laboratory conditions *Ephialtes turionellae* can be reared occasionally on dipterous puparia and also on hymenopterous pupae and therefore may at times act as a secondary parasite.—2-16-39.

LITERATURE CITED

Cushman, R. A. 1913. The Calliephialtes parasite of the codling moth. Jour. Ag. Res. 1(3):211–38. 15 figs., 1 pl.

Howard, L. O., and W. F. Fiske. 1911. The importation into the United States of the parasites of the gipsy moth and the brown-tail moth: A report of progress, with some consideration of previous and concurrent efforts of this kind. U. S. Dept. Ag. Bur. Ent. Bul. 91. 344 pp., 74 figs.

Muesebeck, C. F. W., and D. L. Parker. 1933. *Hyposoter disparis* Viereck, an introduced Ichneumonid parasite of the gipsy moth. Jour. Ag. Res. 46(4):335–47. 5 figs.

Meyer, N. F. 1925. Zur Biologie und Morphologie von *Pimpla examinator* Fabr. (Hymenoptera, Ichneumonidae). Zeitschr. Angew. Ent. 11(2):203–12. 12 figs.

Morley, C. 1908. Ichneumonologia Britannica, iii. The Ichneumons of Great Britain. Pimplinae. xvi+328 pp. London.

Thorpe, W. H. 1930. Observations on the parasites of the pine-shoot moth, *Rhyacionia buoliana*, Schiff. Bul. Ent. Res. 21(3):387–412. 8 figs.

Nutritional Value of Certain Foods for the Adult Honeybee*

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The science of nutrition has demonstrated that certain basic dietary requirements must be fulfilled before an animal organism can develop properly. The animal body needs proteins, fats, carbohydrates, inorganic substances and vitamins, and the requirements are specific, particularly for the proteins, vitamins and mineral elements. The entomologist working in insect physiology must appreciate the significance of protein quality as has been demonstrated for the German cockroach, *Blattella germanica* (L.) (McCay 1938), the indispensability of such inorganic elements as phosphorus to *Tribolium confusum* Duv. (Nelson & Palmer 1935), the vitamin requirements of insects (Trager 1935, Melampy & Maynard 1937) and the effects of the absence of dietary essentials upon insect development (McCay 1938). A study of the dietary requirements of the honeybee, *Apis mellifera* L., is under way at the Southern States Bee Culture Field Laboratory at Baton Rouge, La., and some of the preliminary results are presented in this paper.

Nutrition studies with insects must be conducted under carefully controlled environmental conditions in order that diet may be the most significant variable in the experiment. Woodrow (1935) has shown that low relative humidities tend to lengthen the life of honeybees and has attributed this fact to the greater saturation deficit at the lower relative humidities which permits the insects to lose larger quantities of water into their environment than is possible at the higher humidities.

The purpose of this investigation is therefore twofold: first, to study the ef-

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FIG. 1.—Experimental cage for adult honeybees.

fect of temperature and relative humidity upon the length of life of the adult honeybee; second, to determine the nutritional value of various foods for this insect.

TEMPERATURE AND HUMIDITY STUDIES.—The bees used for these studies were selected at random from a colony of Italian bees. The exact age of the insects was not known. Approximately 50 bees were placed in each experimental cage, fig. 1. The cages (6 by 3¼ by 3 inches) were constructed of wood covered with screen cloth. Water and 50 per cent sucrose solution were provided *ad libitum* from inverted homeopathic vials. The cages containing the insects were placed in constant-temperature cabinets (24 by 24 by 22 inches). The heating element consisted of nichrome wire distributed about the inside walls. The temperature was maintained within 0.5 degrees C. by a bimetallic thermoregulator. In the experiments at high humidities the humidity was controlled by the use of wicks made of Canton flannel (Woodrow 1935), supported by glass rods from the tops of the cabinets while the lower ends were immersed in water or salt solution. At the low humidities it was necessary to use large glass desiccators placed in the constant temperature cabinets, and the control solution was potassium carbonate or calcium chloride.

The results of the temperature and humidity studies are summarized in table 1.

The results in table 1 indicate that the adult honeybee consuming a diet of 50 per cent sucrose can live longest in an environment having a low relative humidity and reasonably high temperature. Low relative humidities provide a high saturation deficit which permits the insects to lose water into their environment, and this effect is increased by the acceleration of evaporation of water at the higher temperature. At the maximum relative humidity the insects at the lower temperature lived longer, but they were not so active as those at the higher temperature. Buxton (1930), working with the larvae of *Tenebrio molitor* L., found that in starvation these insects produce more metabolic water than they would liberate into an environment with a relative humidity of 90 per cent. Honeybees re-

Table 1.—The effect of temperature and relative humidity upon the length of life of the adult honeybee on a diet of 50 per cent sucrose.

EXPERIMENT NO.	TEMPERATURE, DEGREES C.	RELATIVE HUMIDITY, PER CENT	CONTROL AGENT	NUMBER OF BEES	MEAN LENGTH OF LIFE IN DAYS	MAXIMUM LENGTH OF LIFE IN DAYS
1	35	95	Water	250	4.95±0.09	10.0
2	25	95	Water	246	8.23±0.28	21.0
3	35	75	Sodium chloride	255	27.49±0.66	46.0
4	25	75	Sodium chloride	245	15.82±0.40	27.0
5	35	47	Potassium carbonate	61	39.90±1.90	62.0
6	25	47	Potassium carbonate	46	19.70±0.72	33.0
7	35	35	Calcium chloride	49	44.34±1.31	62.5
8	25	35	Calcium chloride	50	15.04±0.64	27.0

ceiving a 50 per cent sucrose solution and living in an environment 95 per cent saturated may contain more water than they can eliminate because of the low saturation deficit. The oxidation of glucose yields 60 per cent of weight as water; *i.e.*, the oxidation of 1 gram-molecule of a hexose such as glucose yields 108.9 grams of metabolic water.

NUTRITIONAL STUDIES.—The bees used in the nutritional studies were approximately 1 day old and had consumed no pollen. They were obtained by screening brood frames prior to emergence. Approximately 50 insects were placed in each experimental cage. Water and pure tupelo honey were provided *ad libitum* from inverted homeopathic vials; the other dietary constituents were fed in small metal cups. Water was provided all experimental groups. Daily mortality records were made, and the physiological efficiency of the experimental diets is expressed as the mean length of life with its standard error.

The results of the nutrition studies are presented in table 2.

In table 2 it will be noted that diets consisting of yellow corn flour (diet 1), patent flour (diet 2), ground whole wheat (diet 3), dried skim milk (diet 6), canned milk (diet 12) and dried bakers' yeast (diet 18) are of little nutritional value when fed alone to adult honeybees, but when the same substances are fed with honey there is an increase in length of life. The bees are maintained by the honey, because when honey was fed unsupplemented (diet 8) the mean length of life was 18.39 days.

Upon dissection of representative specimens it is found that the supplementary foods, such as yellow corn flour, are ingested but are apparently not sufficiently utilized to maintain life. Haydak (1936) reported that cereals such as whole oats flour, whole wheat flour, corn flour and pea flour were not utilized by bees in brood rearing. Fresh pollen (diet 9) is of greater nutritional value than any of the other supplementary foods, for the mean length of life was increased over that of honey (diet 8) and of invert sirup (diet 10). Fresh pollen (diet 9A) was utilized to a small degree when fed without honey. Dried bakers' yeast (diet 18), a rich source of vitamins of the B group and of protein, was apparently of little food value to the adult honeybee. The question of *palatability* is undoubtedly of some importance in the ingestion of diets by insects, as is the case

Table 2.—Nutritive value of various foods for the adult honeybee. Temperature 35 degrees ±0.5 degrees, relative humidity 75 ± 2 per cent.

DIET NO.	DIETARY CONSTITUENTS	NUMBER OF BEES	MEAN LENGTH OF LIFE, IN DAYS	MAXIMUM LENGTH OF LIFE, IN DAYS
8	Honey	326	18.39±0.22	25.0
1	Yellow corn flour	150	1.30±0.06	3.0
1A	Yellow corn flour and honey	196	14.23±0.21	21.0
2	Patent flour	154	2.09±0.03	2.5
2A	Flour and honey	96	15.93±0.47	27.0
3	Ground whole wheat	100	2.00±0.00	2.0
3A	Ground whole wheat and honey	108	15.24±0.43	23.0
6	Dried skim milk	150	1.33±0.06	3.0
6A	Dried skim milk and honey	202	16.17±0.19	23.0
9A	Fresh pollen	263	3.49±0.61	7.0
9	Fresh pollen and honey	291	23.29±0.48	40.5
40	1:3 water extract of pollen and honey	244	17.73±0.29	23.0
38A	Water-extracted pollen and honey	253	14.73±0.28	27.0
41	1:3 ethyl alcohol extract of pollen and honey	234	5.82±0.10	9.0
39A	Ethyl alcohol–extracted pollen and honey	230	13.15±0.26	23.0
42	1:3 water extract of dried bakers' yeast and honey	190	14.74±0.19	19.0
10	Invert sirup	206	12.02±0.22	19.0
11	Fresh pollen and invert sirup	209	23.40±0.29	37.5
12	Canned milk	250	3.06±0.05	4.5
12A	Canned milk and honey	224	17.50±0.34	27.0
18	Dried bakers' yeast	150	1.68±0.03	2.5
18A	Dried bakers' yeast and honey	203	16.64±0.23	25.0

with other animals. Water and 95 per cent ethyl alcohol extracts of fresh pollen were fed with honey (diets 40 and 41), but the extracts have little, if any, nutritional value.

The mean length of life of bees fed water and 50 per cent sucrose solution at 35 degrees C. and 75 per cent relative humidity was 27.49 days (table 1), which was 4 days longer than that obtained, under similar conditions of temperature and humidity, with honey and fresh pollen (diet 9, table 2) or invert sirup and fresh pollen (diet 11, table 2). The results of the two series of experiments are not comparable, because newly emerged bees were used for the nutrition studies, table 2, whereas somewhat older adults were used for the temperature and humidity studies, table 1.

The authors realize that a 50 per cent sucrose solution is not a satisfactory diet for nutrition studies with insects since it is obviously deficient in protein, fat, vitamins and minerals, and that the physiological responses may be complicated by the incompleteness of the diet. Because the honeybee can withstand the winter with little reserve food other than a carbohydrate mixture such as honey, carbohydrate is not necessarily an adequate diet for temperature and humidity studies conducted under widely different conditions. Haydak (1937b) has shown that newly emerged bees can subsist on pure carbohydrate for a long time but the dry weight and nitrogen content of their bodies diminish. The mortality of bees receiving a pure carbohydrate diet is high, but when the pollen is added the bees develop rapidly and commence brood rearing normally. It is evident that more attention must be paid to the nutritional requirements of insects such as the honeybee before the effect of environmental conditions can be studied under laboratory conditions.

The diet of the worker honeybee must furnish energy for such varied activities as collecting and storing nectar and pollen, building comb, affording protection and rearing brood. In addition the diet must provide nutrients which can be utilized to restore depleted tissues and serve as precursors of wax and royal jelly. Haydak (1934) has concluded that the changes in the nitrogen content during the life of the imago worker bee correspond in general to the sequence of activities engaged in by this insect. During the first 5 days there is an increase of more than 92 per cent in the total nitrogen content of the head of the worker. This increase parallels the development of the pharyngeal glands which secrete the royal jelly used in brood rearing. This conclusion, based upon data obtained by chemical analyses, is supported by microscopical examination which shows that the pharyngeal glands of the bees 2 days old are well developed but the secretion is thin and transparent. The nitrogen content of the abdomen increases with age, but that of the thorax increases much more slowly because the flight muscles develop later.

Haydak (1935) has demonstrated that nurse bees can rear brood for a limited time when carbohydrate is the only constituent of the diet. The depletion of the tissue reserves limits the secretion of royal jelly, and consequently the colony is unable to rear brood unless protein and other dietary requirements are provided. The same investigator has reported (1937a) that bees 47 days old are able to live 189 days on a pure carbohydrate diet, but that there is a substantial decrease both in weight and in nitrogen content of all parts of the body. The greatest change takes place in the abdomen.

According to unpublished results from this laboratory, worker bees receiving a diet of honey show a decrease of 1.50 per cent in the total nitrogen content after a feeding period of 7 days and a still further decrease of 5.02 per cent after 14 days. If the honey is supplemented with finely pulverized casein, the nitrogen content increases 4.02 per cent during the first 7 days, and at the end of 14 days there is an increase of 9.00 per cent. These results are in agreement with those reported by Haydak (1936). Keller-Kitzinger (1935) found, however, that the nitrogen content of bees does not change after a carbohydrate diet has been fed to them. The last mentioned investigator did not remove the alimentary tract, and an accumulation of fecal material may have accounted for the results reported.

Pollen is the usual source of protein, but Haydak (1937c) has shown that young bees can develop normally when fed soybean flour, soybean meal, peanut

meal, linseed meal; or soybean meal, linseed meal or cottonseed meal mixed with skim-milk powder, 20 per cent by weight. Only colonies that had pollen or soybean or cottonseed meal mixed with skim-milk powder produced young bees. Haydak had previously (1933) recommended whole milk as a suitable pollen substitute.

CONCLUSIONS.—Experiments at different temperatures and relative humidities indicate that a low relative humidity and a reasonably high temperature are conducive to a long life span of the adult honeybee under conditions that are controlled.

The inadequacy of a carbohydrate diet, such as honey or invert sirup, for the newly emerged adult honeybee has been demonstrated by comparative feeding trials. Fresh pollen is apparently better utilized as a supplement to a carbohydrate diet than any cereal or milk products fed. The authors have not experimented with these diets under apiary conditions.—2-18-39.

LITERATURE CITED

Buxton, P. A. 1930. Evaporation from the mealworm (Tenebrio: Coleoptera) and atmospheric humidity. Proc. Roy. Soc. London (B) **106**(747):560–77, 8 figs. Aug. 5.

Haydak, M. H. 1933. Der Nährwert von Pollenersatzstoffen bei Bienen. Arch. f. Bienenkunde **14**: 185–219.

Haydak, M. H. 1934. Changes in total nitrogen content during the life of the imago of the worker honeybee. Jour. Ag. Res. **49**(1):21–8. July 1.

Haydak, M. H. 1935. Brood rearing by honeybees confined to a pure carbohydrate diet. JOUR. ECON. ENT. **28**(4):657–60. Aug.

Haydak, M. H. 1936. Value of foods other than pollen in nutrition of the honeybee. JOUR. ECON. ENT. **29**(5):870–7. 1 fig. Oct.

Haydak, M. H. 1937a. Changes in weight and nitrogen content of adult worker bees on a protein-free diet. Jour. Ag. Res. **54**(10):791–6. May 15.

Haydak, M. H. 1937b. The influence of a pure carbohydrate diet on newly emerged honeybees. Ann. Ent. Soc. Am. **30**: 258–62. June.

Haydak, M. H. 1937c. Further contribution to the study of pollen substitutes. JOUR. ECON. ENT. **30**(4):637–42. 1 fig. Aug.

Keller-Kitzinger, R. 1935. Kann die erwachsene Arbeiterin der Honigbiene (*Apis mellifica*) Eiweiss Verwerten? Ztschr. Vergl. Physiol. **22**: 1–31. Illus.

McCay, C. M. 1938. The nutritional requirements of *Blattella germanica*. Physiol. Zool. **11**(1):89–103. 3 figs. Jan.

Melampy, R. M., and L. A. Maynard. 1937. Nutrition studies with the cockroach (*Blattella germanica*) Physiol. Zool. **10**(1):36–44. 1 fig. Jan.

Nelson, J. W., and L. S. Palmer. 1935. The phosphorus content and requirements of the flour beetle *Tribolium confusum* Duval, and a study of its need for vitamin D. Jour. Ag. Research **50**(10): 849–52. May 15.

Trager, William. 1935. On the nutritional requirements of mosquito larvae (*Aedes aegypti*). Amer. Jour. Hyg. **22**(2):475–93. Sept.

Woodrow, A. W. 1935. Some effects of relative humidity on the length of life and food consumption of honeybees. JOUR. ECON. ENT. **28**(3):565–8. 1 fig. June.

SCIENTIFIC NOTES

Observations on *Collabismodes cubae* Boh. as a Tomato Pest

The beetle *Collabismodes cubae* Boh., reported (U. S. Department of Agriculture 1939) by J. R. Watson of the Florida Agricultural Experiment Station, as infesting tomato plants, was brought to the writer's attention early in March by G. D. Ruehle, of the Florida Subtropical Experiment Station at Homestead, who had sent specimens to Dr. Watson at Gainesville.

When first observed the infestation occurred principally in a tomato field lying just north of the Florida City Canal in Dade County and about a mile from Biscayne Bay. This was one of the most southeasterly located cultivated fields in Florida. The location of the infestation suggested that the insect had reached Florida in floating plant remnants or had been carried by wind from Cuba, approximately 175 miles.

The observations indicated that the insect was capable of becoming an extremely serious pest of tomato plants if it were able to spread and become established farther north. As it is a tropical species, the chances are good that it may not spread much farther north and that it may not survive the summer when the lands in the location of the infestation are flooded, as they often are for several weeks.

In the first week of March the larvae were nearly full grown and occurred at the rate of 1 to 4 per plant. The larvae fed by burrowing in the main stem from below the surface of the soil to a point 2 or 3 inches above ground. When there were several larvae per plant the stems were well hollowed out.

The infestation was spotted in the field. Occasionally as many as a score of plants in one spot

were severely injured, and such plants finally died. But the total injury did not seem to be great. Probably no more than 1 per cent of the plants was killed.

The larvae were uniform in size when first observed and seemed to represent a distinct brood. They pupated within about a week during the last of March, and by the end of that month all those observed were pupae. When through feeding the larvae constructed elliptical cocoons of fragments of the tomato stem. These were located within the larval burrows. The resulting beetles gnawed directly through the cocoons and the adjoining stem to attain freedom. A total of 34 pupae were found in 20 tomato plants, an average of 1.7 per plant.—6-20-39.

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LITERATURE CITED

U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine. 1939. Insect Pest Survey Bulletin 19(2):44. Mimeo.

Observations on the Flight of Adults of the Sugar-Beet Wireworm, *Limonius californicus* (Mann.)

Although it has been known for a long time that adults of the sugar-beet wireworm, *Limonius californicus* (Mann.) are capable of flight, no information has been published to indicate whether the females which take to flight are gravid. It has been observed that females of *L. californicus* ordinarily enter the soil soon after they are fertilized, and it is believed that they deposit the greater part of their eggs in close proximity to the place in the soil from which they originally emerged. At Parma, Idaho, in May, 1937, collections of *L. californicus* adults in flight were made by the use of a standard insect net. It was found that most of these insects were females. A total of 35 of these females were placed in cans of moist soil in the laboratory, where they deposited on an average 39 eggs each.

In 1938 a more extensive series of flying adults of this same species was collected daily in an alfalfa field during the period April 30–May 29. It was again noted that the majority of beetles collected in flight were females. Maximum flight activity usually occurred between 2 and 4 p.m. on still days when temperatures in the shade ranged from 70 to 80 degrees F. The distances flown by the adults of *Limonius californicus* varied considerably, but in many instances, particularly on warm days, the beetles soared to a height of 30 feet or more and flew as far as the eye could follow, and beyond. Cool and windy weather following the flight of April 30, 1938, prevented further flight until May 12. From May 12 to 26, flights occurred on 10 days, and thereafter no flights of any consequence were observed. A record of the adults collected in flight during 1938 and of the eggs subsequently deposited by the females is given in table 1, at bottom of page.

The 21 females collected on April 30 laid on an average 85.7 eggs each, with a range of 8 to 181. The average egg production for this species, over a period of years, is 175 eggs per female. Thus, the females which took to flight on April 30 were apparently still carrying about 50 per cent of their original quota of eggs. The females collected during the 1938 flight season laid an average of 38.8. each, which is roughly 22 per cent of the normal egg production of this species in the Pacific Northwest.

These findings seem to show that the spread of the sugar-beet wireworm from one locality to another is due to flight by the females carrying approximately 50 per cent of their original quota of eggs.—6-20-39.

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Table 1.—*Limonius californicus* adults collected in flight in 1938 and the egg production of the females after capture.

DATE OF COLLECTON 1938	NUMBER OF MALES	NUMBER OF FEMALES	PERCENTAGE OF FEMALES	TOTAL NUMBER OF EGGS	AVERAGE NUMBER OF EGGS PER FEMALE
April 30	0	21	100.0	1,799	85.7
May 12	18	228	92.6	8,321	36.5
May 13	2	23	92.0	538	23.4
May 14	4	47	92.1	1,606	34.2
May 20	0	13	100.0	514	39.5
May 21	6	91	93.8	4,203	46.2
May 23	4	88	95.6	4,687	53.2
May 24	1	14	93.3	908	64.9
May 25	11	153	93.2	4,286	28.0
May 26	1	64	98.4	1,973	30.8
May 29	0	1	100.0	0	0.0
Total	47	743	94.0	28,835	38.8

Aphid Transmission of the Virus Causing White Streak of Narcissus

White streak of narcissus has been recognized for approximately a decade (Chittenden 1933, McWhorter 1938), but it was not until 1939 that the disease was known to be caused by a virus.* Up to the present time there has been no mention of the manner in which this virus is disseminated under natural conditions. It is the purpose of this paper,

* Unpublished manuscript by F. A. Haasis.

Table 1.—Results of experiments with *Illinoia solanifolli* and *Aphis rumicis* as vectors of the virus causing white streak of narcissus, 1938.

VECTOR	DATE OF TRANSFER*	LOCATION OF CAGES	HEALTHY NARCISSUS PLANTS EXPOSED, NUMBER	PLANTS INFECTED, PER CENT
Illinoia solanifolii	February 17	Greenhouse	24	67
Check (no apids)	—	Greenhouse	23	0
Aphis rumicis	May 1 to 10	Field	80	81
Check (no aphids)	—	Field	74	9

* Symptoms of the disease appear following the year of inoculation.

therefore, to report two species of aphids as vectors of the white streak virus, namely the potato aphid, *Illinoia solanifolii* (Ashm.), and the bean aphid, *Aphis rumicis* L.†

In all transmission tests the aphids were placed directly into the cages containing both healthy and infected narcissus plants. This was accomplished by transferring small portions of the native host into the cages, from which the aphids were allowed to disperse freely. The narcissus plants used were all of the King Alfred variety. The potato aphids were grown on potatoes from a pure-line colony, originating from a single aphid, and the bean aphids were taken from *Rumex* spp., the overwintering host.

Aphids were not used in the control tests since some of the cages contained infected plants.

The desirability of maintaining a permanent reference collection for the known vectors of plant pathogens has been suggested by Smith (1937); therefore, specimens from the type colony of *Aphis rumicis* have been preserved in the United States National Museum, under the accession number T. C. 6,631.

In greenhouse tests with *Illinoia solanifolii*, 67 per cent of the plants became infected, whereas all the plants in the control lots remained healthy, table 1. In field tests with *Aphis rumicis* infections ranged from 75 to 90 per cent, with an average of 81 per cent, and in the control lots from 5 to 13 per cent, with an average of 9 per cent.

A total of seven accidental infections appeared in the control tests involving 74 plants, table 1. It is not known just why these accidental transmissions occurred, but two possibilities are suggested in another paper‡ on the mosaic disease of narcissus.

On the whole, aphids are as effective in transmitting the virus causing white streak as they are in transmitting the virus causing narcissus mosaic (Blanton and Haasis 1939; also in unpublished manuscript by the same authors). Natural transmission was very high in some of the uncaged plants growing in the field adjacent to the caged plants. In 8 uncaged plots containing a total of 153 plants the infection ranged from 25 to 85 per cent, with an average of 67 per cent.—7-13-39.

F. S. BLANTON, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.*

LITERATURE CITED

Blanton, F. S., and F. A. Haasis 1939. Transmission of the narcissus mosaic virus by aphids. JOUR. ECON. ENT. 32(3): 469–70.

Chittenden, F. J. 1933. Mosaic disease of narcissi. Royal Hort. Soc. Daffodil Yearbook 1933: 72–3.

McWhorter, F. P. 1938. Narcissus mosaic and early maturity. U. S. Dept. Ag., Bur. Pl. Indus., Pl. Dis. Rep. 22: 147–8. Mimeo.

Smith, F. F. 1937. The need of permanent reference collections of insect vectors of plant diseases. Phytopath. 27: 198–202.

† The aphids were identified by P. W. Mason of the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture.

‡ Unpublished manuscript by F. S. Blanton and F. A. Haasis.

Notes on the Sugar-Beet Root Aphid in California

Although no special investigations have been made on the sugar-beet root aphid, *Pemphigus betae* Doane, by the writer, it seemed a rather interesting observation that in the Half Moon Bay area during 1938 asexual viviparous forms were found every month on or about the roots of curly dock, *Rumex crispus* L., without any evidence of sexual forms being produced. No evidence of a sexual generation migrating to poplars was found and poplars were not found within 10 miles of the area where populations on dock were maintained. This would seem to indicate that this species does not have to resort to the formation of sexual forms in this region, but is able to maintain itself through the continuous formation of asexual generations.

Doane (1900), in describing *Pemphigus betae* from beets in Washington, reported that the winged forms appear during the summer and fly to other beets where they start new colonies. No migration to another host in winter was reported. In 1914, however, Parker (1914) in Montana was able to demonstrate the complex life history of this species and definitely trace its migration to poplars in the fall. Gillette & Bragg (1915) in Colorado were able to demonstrate migration to poplars during September and October and mentioned the work of Maxson in which he found that the form producing galls on poplars was found to be *P. balsamiferae* Williams. Maxson (1916) in rearing experiments was able to colonize spring migrants of *balsamiferae* on sugar beets and regarded *balsamiferae* Williams as a synonym of *P. betae* Doane, the latter having priority. Swain (1919) suggested that other species may be involved besides *P. betae* Doane on beets and other hosts during the summer. Essig (1929) reported the species as having a wide distribution in the western states and listed the summer and winter hosts. Gillette & Palmer (1934) pointed out the similarity of *balsamiferae* and *betae*, but mentioned that *betae* had not been found on poplars in its native territory. They reported *balsamiferae* as forming pocketlike galls on the underside of poplar leaves during the winter with migration to beets and *Chenopodium* in summer.

At Half Moon Bay the first alate from dock emerged February 25, 1938, in cellophane cages covering infested dock plants. Alates continued to emerge during March and again in September and October. Other docks in the same region, namely, *Rumex conglomeratus* and *R. salicifolius* were not as vigorously attacked as *crispus*, which was undoubtedly the preferred host. A few beets were planted experimentally in the Half Moon Bay area during 1938, but there was no evidence that the spread of infestations on dock could be attributed to this host. Alates were determined by Professor E. O. Essig as *Pemphigus balsamiferae* Williams (commonly known as *P. betae* Doane).

It is hoped that these notes may help promote some further investigations in California on this group of aphids. The behavior of this species in Washington and California does not seem to be the same as in Colorado and Montana, which would either indicate biological differences in the same species due to differences in climatic factors or to the possibility that several species are involved.—7-14-39.

W. H. LANGE, JR. *University of California, Berkeley.*

LITERATURE CITED

Doane, R. W. 1900. Notes on a new sugar-beet pest, with a description of the species. Ent. News. **11**: 390–1.

Essig, E. O. 1929. Insects of Western North America. The Macmillan Co., p. 261.

Gillette, C. P., and L. C. Bragg. 1915. Notes on some Colorado aphids having alternate food habits. JOUR. ECON. ENT. **8**: 97–8.

Gillette, C. P., and M. A. Palmer. 1934. The Aphidae of Colorado. Ann. Ent. Soc. of Am. **27**(2): 222–3.

Maxson, A. C. 1916. Some unpublished notes on *Pemphigus betae* Doane. JOUR. ECON. ENT. **9**: 500–4.

Parker, J. R. 1914. The life history of the sugar-beet root louse (*Pemphigus betae* Doane). JOUR. ECON. ENT. **7**: 136–41.

Swain, A. F. 1919. A synopsis of the Aphididae of California. Univ. of Calif. Pub. Ent. **3**(1): 142–3.

A Recent Pecan Pest, *Cacoecia infumatana* (Zell.)

During the past 4 years, a tortricid identified by Carl Heinrich as *Cacoecia infumatana* has attracted much attention as a pest of pecans in Opelousas, La., and vicinity. The infestation was first observed in the spring of 1936 when several contiguous trees in Opelousas were completely defoliated by the larvae. These same pecan trees have been defoliated each spring since 1936 by *C. infumatana*, and, in addition, the infestation has spread to other trees in the town and to points as far as 25 miles from Opelousas.

Of special interest is the fact that even though pecan trees are very numerous in the infested area, the infestation is very spotted, often with innumerable trees between infested points. It is not uncommon to find one or more trees completely denuded of foliage, whereas surrounding trees may not contain even a single nest of larvae.

Although the life history of this species has not been studied in detail, it appears that there is only one generation a year. The eggs are laid on the branches during the latter half of May and hatch the following spring at the time when the leaf buds are opening—about April 1. The larvae are gregarious, and a colony feeds inside of a nest that is composed of webbed-up leaves and small branches. Many of the larvae pupate in the nests, whereas others, especially if food becomes scarce before they are fully mature, crawl down the branches and trunks of the infested trees, spinning a continuous web as they go, and pupate on vegetation, on the base of the trees, on fences and other objects on or near the ground. Weeds growing under infested trees have been observed to be completely covered with a heavy web made by the caterpillars. The complete life history requires about 30 to 40 days, and when the adults emerge the females can be distinguished readily from the males by their greatly distended abdomens, which contain mature eggs.

The nests in which the larvae feed are thick and very dense, and when they are opened give off an obnoxious odor, which is due, no doubt, to the accumulation of cast skins, parasitized and diseased larvae.

No previous account of economic importance of this species has been found.—7-27-39.

L. O. ELLISOR, *Louisiana Agricultural Experiment Station, University.*

Microterys titiani Gir., An Egg Predator of *Lecanium corni* Bouché

In certain regions of California the European fruit lecanium, *Lecanium corni* Bouché, is a pest of major importance. The University of California Citrus Experiment Station has undertaken a project to introduce natural enemies of this scale from Europe in hopes of controlling it. Certain of the imported European parasites were found to be rather close taxonomically to parasites already reported from California. It was with interest, therefore, that early in June, 1939, a heavy infestation of *L. corni* on manzanita was taken near Idyllwild, Calif., and brought into the laboratory in order to rear the parasites.

At this time the female scales were at the height of egg laying, and the area under the scale was generally filled with eggs. Somewhat surprisingly, however, chalcid larvae were found feeding on the eggs externally beneath the scale. At first they were mistaken for the larvae of *Scutellista cyanea*, Motsch., which they resembled closely and which was the only known egg predator working on lecanine scales in this locality. However, larvae were isolated in small glass cells with enough *L. corni* eggs to reach maturity and, instead of developing into *Scutellista*, the adults turned out to be *Microterys titiani* Gir.

Silvestri (1919) has shown that another species, *Microterys sylvius* (Dalm.) occurring in Europe has this same habit of feeding externally to the scale on the eggs. The other known species of *Microterys* are endoparasites. Since Silvestri's work does not include a complete life history study, it may be of value to comment here, on that of *M. titiani* Gir.

Microterys titiani Gir. has been reared from the egg to the adult when isolated with eggs of *Lecanium corni* in small glass cells. The eggs are colorless to pale pink, closely resembling the coloration of the *L. corni* eggs. Because of this it often requires in-

tensive searching to find a *Microterys* egg which has been deposited among the *L. corni* eggs. The egg of *M. titiani* is pedicellate, the over-all length is approximately 0.40 millimeters, the body 0.23 millimeters and the pedicel 0.17 millimeters. The width is approximately 0.09 millimeters. In comparison a *L. corni* egg averages about 0.32 millimeters in length and 0.14 millimeters in width.

Immediately after hatching, the first instar larva starts actively feeding. It is a generalized, vermiform larva having a peripneustic tracheal system. The following three instars differ from the first mainly in size. The fourth instar is followed by a prepupal stage which is distinguished from the fourth instar by a marked enlargement of the thoracic segments, the cessation of feeding and most movement, and a reduction in length. The meconium is cast by this stage just before entering the true pupal stage. Table 1 shows the approximate average sizes and length of time spent in each stage.

Table 1.—Approximate average sizes of *Microterys titiani* Gir. larvae and length of time spent in each stage.

INSTAR	TIME DAYS*	LENGTH IN (MILLIMETERS)
First	2	0.48 (0.32–0.65)
Second	1	1.00 (0.50–1.30)
Third	1	1.28 (0.98–1.42)
Fourth	4	2.25 (1.32–2.88)
Prepupa	1	1.90 (1.75–2.08)
Pupa	8	1.68 (1.60–1.75)
Total	17	

* Room temperature Riverside, California, June 24–July 13, 1939.

The larvae of *Microterys titiani* are gregarious feeders, from 1 to 10 having been found beneath single scales. The adults emerge through an irregular hole gnawed usually near the base of the scale. The adult female apparently does not oviposit until later in the summer or fall, since the ovarioles remain in an immature condition for at least two weeks after emergence.—7-30-39.

PAUL DEBACH, *University of California Citrus Experiment Station, Riverside.*

LITERATURE CITED

Silvestri, F. 1919. Contribuzioni alla conoscenza degli insetti dannosi e dei loro simbionti V. La Cocciniglia del Nocciuola (*Eulecanium coryli* L.). Boll. Lab. Zool., Portici. **13**: 127–92. 34 figs.

Tandem Doses of Calcium Cyanide for Controlling Insects on Plants

In November, 1936, the American Cyanamid and Chemical Corporation established an investigational project with the Illinois Natural History Survey and the University of Illinois under the supervision of W. P. Flint and C. C. Compton. It was the aim of the investigation to (1) check, under known conditions, the results being reported by commercial users of *Cyanogas* and (2) to develop a more efficient method for the use of *Cyanogas* to control certain greenhouse insects.

To fulfill these aims the work was divided into three distinct phases, and although all the work was done concurrently only brief reports will be given here concerning the results of the regular weekly fumigation at 7- to 10-day intervals with light doses of *Cyanogas* and the results with stronger dosages of *Cyanogas* for shorter exposures.

Briefly, the results of these tests were as follows.

Two greenhouses were fumigated regularly at 7- to 10-day intervals with *Cyanogas* G-fumigant, one-fourth ounce per 1,000 cubic feet. The cumulative action of this series of fumigations resulted in very satisfactory control of fern scale, *Hemichionaspis aspidistrae* (Sign.); Mexican mealybug, *Phenacoccus gossypii* Towns. & Ckll., infesting chrysanthemums, kalanchoes and African violets; Florida red scale, *Chrysomphalus aonidum* (L.), infesting many varieties of palms and related plants; the greenhouse whitefly, *Trialeurodes vaporariorum* (Westw.), infesting geranium and begonia; and the chrysanthemum aphid, *Macrosiphoniella sanborni* (Gill.), infesting chrysanthemum. There was no apparent injury to the host plants mentioned. This treatment failed to control a common thrips, *Thrips nigropilosus* Uzel., infesting chrysanthemum; the citrus mealybug, *Pseudococcus citri* (Risso), infesting chrysanthemums, gardenias and kalanchoes; the grape mealybug, *Pseudococcus maritimus* (Ehrh.), infesting *Asparagus sprengeri* in hanging baskets; and the common red spider, *Tetranychus telarius* (L.), infesting many different greenhouse plants.

A series of tests with heavy charges of *Cyanogas* G-fumigant at short exposures indicated that 2 ounces of this material for each 1,000 cubic feet of space left in for 2 hours would give satisfactory control of the citrus mealybug, *Pseudococcus citri*, on gardenias without injury to the plants. Such treatments were not satisfactory for the control of thrips, as the toxic concentrations were definitely in the burning zone for the host plants, in this case chrysanthemums.

Since *Thrips nigro-pilosus* were not controlled successfully by either of the foregoing methods, a series of tests was planned to determine whether these insects could be controlled without injuring chrysanthemum.

A third phase of the work, fumigation chamber experiments, was handled almost entirely in a 1,000 cubic foot fumigation chamber. The plants and insects were introduced from greenhouse sources. For handling the thrips, cages were constructed by covering with organdy 2-inch openings in the ends of half-pint cardboard ice cream containers. The organdy was shellacked in position and the thrips could not escape from these containers, yet the gas could readily penetrate. Thrips could be kept alive in the cages for several days by fresh chrysanthemum leaves placed in the cages and a high humidity maintained by keeping one end of the carton above water while the other end was covered by glass. Standard *Ball Mason* jar lids were found convenient for water cups as the carton fitted over them nicely, while Petri dishes served well for the glass cover. Fumigated thrips were found to appear dead or quite stupefied immediately following the treatment, regardless of its strength; hence all thrips were held at least 4 hours before counts were made to determine per cent of control. Both adult and immature thrips were used and in some cases separate results were taken to check the relative susceptibility of the different aged insects to cyanide gas.

Some workers have indicated that the degree of

maturity is an important factor in thrips control. Past results have indicated that adults were more readily killed by cyanide than were the nymphs. This is contrary to my results, which indicate that there is not much difference in their resistance, but any difference there is seems to be in favor of the adults since they were a little more difficult to control than the nymphs.

Many dosage and exposure combinations were tried, but regardless of the combination, injury occurred on the chrysanthemums if a worthwhile kill of thrips was obtained. Since it seemed impossible to control thrips on chrysanthemums by conventional use of *Cyanogas*, and since it was noted repeatedly that fumigated thrips, regardless of the dose, always appeared dead immediately following the experiment, I decided to try something different by subjecting the insects to successive charges of gas, any one of which was too weak to give satisfactory control. This method I have termed "tandem" fumigation. The charges of gas were separated by intervals of ventilation, the timing regulated so that the successive charge would catch the insects just as they were recovering from their stupor. It was thought, too, that the plants would not be so greatly injured if they were aired between charges.

The results of tests with this tandem method were very encouraging, although much was left undetermined because of the time-consuming nature of this work and because of the large number of possible variables. No help could be gained from the literature and hence many errors were made. It is hoped that from this start someone may develop a method of controlling more resistant insects on the more susceptible plants. It must be kept in mind that this work is only preliminary and the results only an indication of what may be possible.

To illustrate the advantage of the tandem method, the following results are reported: Thrips were fumigated with one-half ounce *Cyanogas* G-fumigant for 1 hour without any control; yet slight tip burn resulted on chrysanthemums. Thrips and plants fumigated for an hour with one-half ounce, then aired for 3 hours and subjected to another fumigation exactly like the first showed 28.4 per cent control, and the chrysanthemums were none the worse burned. Thrips and chrysanthemums thus treated and then aired 2 more hours and fumigated showed 89.6 per cent control of thrips; yet the chrysanthemums treated in this way were still not burned more than were those subjected to only one charge of gas.

Several other experiments conducted in a similar manner gave very encouraging results. That is, the increase in control was always noticeable while the effect on the plants was about the same whether they were exposed once or three times. Although satisfactory control was never obtained without some injury to the host plants, the tandem method gave results much nearer to the desired goal than was obtained by the conventional method. Regardless of the rather encouraging results obtained in these fumigation chamber tests, a great deal of time would be necessary to develop this technique to a point of usefulness, and even though it were possible to use this method it still has several obvious disadvantages. First of these would be the difficulty of getting the greenhouse men trained to use it properly. Second, it requires more of the operator's time. Its use is mentioned here only because I believe it widens the range of possibilities for insect control on plants with cyanide.—8-5-39.

W. E. MCCAULEY, *Illinois Natural History Survey, Urbana.*

JOURNAL OF ECONOMIC ENTOMOLOGY
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A Half Century of Achievement

IN a recent issue of the JOURNAL OF ECONOMIC ENTOMOLOGY, Professor J. S. Houser commented on the increasing demand made upon professional entomologists from a variety of sources. This timely note suggests some comment on the growth of entomological activities during the past half century, a period representing the life of the Association of which the JOURNAL is the official organ.

It takes only a cursory review, at least for those of us who have had the opportunity to watch this growth for any considerable period, to make us appreciate what wonderful strides our branch of knowledge and service has made in the passing years. Fifty years ago the first annual meeting of the Society of Economic Entomologists was held at Washington. A year later I attended the meeting at Urbana, where the JOURNAL is now edited. The attendance there was recorded as 24; 10 of those in attendance are, I believe, still living, which speaks well for the longevity of entomologists. At our recent annual meetings the number in attendance has been in the hundreds, and the men engaged in professional work in entomology are numbered by thousands. This expansion holds not only for the United States and Canada where there has been tremendous growth, but for many other countries, probably most conspicuously in the British Empire, where the Imperial Bureau of Entomology has made notable advances. While it is impossible in a short space to review the different phases of growth in detail, it will serve to illustrate the point by citing some of the more striking cases.

Fifty years ago only a very few colleges were giving instruction in entomology and that in very limited courses. Now practically every important university and many colleges are giving such instruction and many carry such work to the doctor of philosophy degree. In medical science there has been a notable increase in recognition of insect-caused disease or of insect vectors for many pestilential forms. Practically the whole history of modern biological control is included in the half century, and many other phases of control based on ecologic grounds have had their most important advances within this period.

In the special fields of forest entomology and cotton pests, truck crop insects, citrus orchard pests, insects affecting man and animals, and household pests the lines of work and number of trained workers have been increased many fold.

Expansion in such lines has been accompanied by a large expansion in ouput of bulletins, journals, books, circulars and leaflets for the dissemination of knowledge about insects and their control.

The tremendous growth of the insecticide manufacturing industry from almost zero to a business involving many millions of dollars is impressive from the commercial point of view. In addition to the insecticide manufacturing industry, there is now an extensive business carried on by firms engaged in protection of shade trees and ornamental shrubbery; in termite control, house fumigations, mill pest control and others of perhaps less importance.

The manufacture of insecticide machinery, starting with crude hand pumps and simple nozzles, has developed into a large industry involving a great variety of sprayers and dusting machines with power methods of distribution, both on the land and in the air.

The age old branch of apiculture has seen many improvements. Inspection and quarantines have had their growth and applications all within the history of our Association and much of it due to the persistent and judicious efforts of its members.

We may well query, what of the future? Probably no one will venture any forecast without reservations. It is most obvious that recent discoveries have served simply to disclose unending vistas of needed research and it should follow that there will

be demand for trained workers in ever increasing numbers. Teachers, research men in national and state service, extension agents and workers in increasingly large numbers in private commercial organizations would seem a necessity if our civilization and the control of insects, often cited as humanity's greatest menace are to be carried forward successfully. Perhaps a larger part of the cost of such service must rest upon the individuals calling for it. The national and state services cannot be expected to expand indefinitely or to cover every demand for personal assistance. These may be limited to wide-spread outbreaks and the study of broad basic problems of national or statewide importance. There should be a place for the trained expert in control measures, and his compensation should rank with that of the consulting chemist or engineer whose function in society has long been recognized. Advances in this direction appear to be on the way and deserving of sympathetic support.—9-29-39.

HERBERT OSBORN

REVIEWS

Nomenclator Zoologicus: A list of the names of genera and subgenera in zoology from the tenth edition of Linneaus, 1758, to the end of 1935; in four volumes. Edited by Sheffield Airey Neave. Published by the Zoological Society of London, Regent's Park, London, N.W. 8. 8 guineas, post free.

This volume lists alphabetically all the generic names in zoology from Linnaeus to the end of 1935 and will be a great boon to all taxonomists in the field of zoology. The first volume has now appeared and comprises the letters A to C, inclusive; the remaining three volumes are planned to appear at intervals of about 6 months.

Entomologists should find great use for this work, especially those engaged in taxonomic fields. In the selection of new names for genera, there is always the danger that, unless checked against some reliable source such as this *Nomenclator*, the name will have already been used in zoology. The resulting confusion and inconvenience can be eliminated to a large extent by the exercise of a little care on the part of the describer. As an aid to this sort of thing we are very glad, indeed, to see the appearance of this work by Dr. Neave. This, of course, is by no means the first of its kind but brings the comprehensive listing of these names down to a later date than any other volume.—7-21-39.

H. H. Ross, *Illinois Natural History Survey, Urbana.*

Principles of Forest Entomology, Second Edition, by S. A. Graham. Pages i–xvi, 1–410, 165 text illustrations. McGraw-Hill Book Co., Inc., New York, N. Y., 1939.

This most welcome revision of an important and exceedingly valuable work is, like the earlier edition, primarily ecological. It is a discussion of cause and effect in relation to insect injuries in American forests and the possibilities of reducing or limiting damage under woodland conditions. If it be granted at the outset that direct control measures are too costly in the average forest, it follows that control must be achieved largely by forest management or forest practices, and it is to this end that the author addresses himself largely; in the reviewer's judgment he is abundantly justified. A concrete illustration of this appears on pages 244 and 245 in a tabular and diagrammatic presentation of Keen's Ponderosa Pine Classes and Risks, a condition which is found in one form or another in other as well as forest trees.

This book is the only text on forest entomology strictly applicable to North American conditions. The revision brings the volume down to date and includes, among other matters not appearing in the original volume, a summary account of contemporary work and workers in America, historical matter of much interest to the younger entomologists and foresters. The chapter on insect abundance with its discussion of biotic balance and the relation between abundance and environmental factors has been largely rewritten to include the results of investigations in the past decade. The same is true of the account of termites, the discussion of bark beetles and insect-caused losses.

New accounts add to the value of the revision; namely, several pages on quarantine and embargoes, and inspection and certification, a brief discussion of the part these methods play in preventing the dissemination and rapid spread of destructive forest insects.

Discussions of the Pandora moth, the European pine shoot moth, the European spruce sawfly and Melanophila beetles are also new additions. There is a new chapter dealing with some indirect effects of forest insects such as insects and wood rots and stains, insects and parasitic fungi and insects and virus diseases, followed by a brief survey of possible future developments. In the discussion of wood destroyers, a subhead for the horntails appears to have been inadvertently dropped. An extensive bibliography and an excellent index add greatly to the value of the work.

We have in this revision a comprehensive discussion of the principles which should guide the forest entomologist and the forester in determining operations in the future. The problems may change somewhat from decade to decade because of increased abundance of species previously of little importance in forests or, as has occurred in the past decade, because of the introduction and rapid multiplication of insects from other countries. Experiences with these latter indicate to some extent the possibilities of silvicultural practices and suggest that introduction of natural enemies may play an important part in controlling introduced pests. The reviewer recommends the volume unhesitatingly to all who must solve problems falling within the scope of this work.—8-31-39.

E. P. FELT, *Bartlett Tree Research Laboratories, Stanford, Conn.*

OBITUARY

John Harney Lovell 1860–1939

Born at Waldoboro, Me., October 21, 1860, John Harney Lovell was educated at Amherst College, taking his bachelor's degree there in 1882 and his master's degree in 1899.

He was the author of several publications. The most important were *The Flower and the Bee*, published in 1918, and *Honey Plants of North America*, published in 1926.

He was widely known as a botanist, apiculturist and horticulturist. He was biological editor of *ABC and XYZ of Bee Culture*, 1926.

He died August 2, 1939.

Heinrich Hugo Karny 1886–1939

Heinrich Hugo Karny was born in 1886 and died in 1939. He was granted a Ph.D. from Vienna in 1909 and the degree of M.D. in 1915. Known principally as an entomologist, he did some work in general zoology. He was the author of many comprehensive papers on various groups of the Orthoptera, including a *Genera Insectorum* fascicle on the Gryllacrididae. He also published important papers on Thysanoptera and Corrodentia. He was an author of *Biologie der Wasserinsekten*, published in 1934. From about 1919 to 1930 he was Zoologist in the Zoological Museum, Buitenzorg, Java. Afterwards, at Graz, Austria, now Germany, he was a tutor in the Karl Franzens University.

CURRENT NOTES

Retirement of E. C. Van Dyke

After 26 years of service, Dr. E. C. Van Dyke, Professor of Entomology at the University of California, retired with the title *emeritus* on July 1, the *Experiment Station Record* reports. He will be succeeded by Dr. E. O. Essig, whose work will be taken over by Dr. Guy F. MacLeod, Professor of Economic Entomology at Cornell University. Dr. E. Gordon Linsley has been added to the University of California staff as an instructor and will be stationed at Berkeley. Dr. Robert L. Usinger has been added to the staff in a similar capacity and will be located at Davis.

Annual Meeting of Entomological Society of Ontario

The Seventy-sixth Annual Meeting of the Entomological Society of Ontario was held November 2–4. Headquarters for the meetings were at the Chateau Frontenac.

The local committee, under the chairmanship of Dr. George Maheux, arranged special features and entertainment such as a visit to the Rangers' School at Duchesnay and a tour of historical Quebec. This was the first meeting of the society to be held in the city of Quebec.

Eddy Appointment Announced

Announcement has recently been made of the appointment of Brayton Eddy, lecturer on entomology, as Administrator of the Office of Entomology for the state of Rhode Island.

Kearns to Teach

Dr. C. W. Kearns, who for the past 4 years has served as Special Research Assistant in the Illinois Natural History Survey and Illinois Agricultural Experiment Station resigned in August to join the staff of the Department of Entomology at the University of Illinois.

Dr. Kearns will work especially in the field of insect toxicology and plans to continue his research in the development of organic insecticides. Dr. Kearns received his bachelor's degree from Colorado State College, his Master of Science and Doctor of Philosophy from the University of Illinois.

Assistant to Lee A. Strong

Dr. John T. Creighton, Head of the Department of Entomology of the University of Florida, was appointed Consultant and Adviser to Dr. Lee A. Strong, Chief of the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, for the period May 24 to September 15, 1939. During this period Dr. Creighton made a survey of all maritime, Mexican and Canadian border ports of entry for the Division of Foreign Quarantines. A report is now being formulated which will include specific recommendations.

New Section in *Biological Abstracts*

Entomologists, horticulturists and foresters, often concerned with the interrelationships of climatic and meteorological factors to the organisms with which they work, will welcome the announcement that *Biological Abstracts* is undertaking to set up a new section, *Bioclimatology-Biometeorology*, to appear within the section *Ecology* under the editorship of Robert G. Stone of the Blue Hill Observatory of Harvard University. Institution of this new section should assure a more nearly complete abstracting and segregation of current literature in bioclimatology and biometeorology.

Mexican Bean Beetle in Louisiana

The first Mexican bean beetle infestation in Louisiana occurred in the extreme eastern part of the state at Bogalusa late in 1938, C. O. Eddy, Entomologist reports. The infestation has increased thus far in 1939 to occupy the entire city, an area of four miles in diameter.

BECNEL TO LOUISIANA AGRICULTURAL EXPERIMENT STATION

I. J. Becnel of Lucy, La., joined the staff of the Louisiana Agricultural Experiment Station as Assistant Entomologist in June, 1939. He is in charge of research on cotton and citrus pests. Mr. Becnel is a graduate of Louisiana State University, where he received his master of science degree in 1932. He spent the year 1938–39 at Ohio State University doing work toward his Ph.D. degree.

NEW ASSISTANT AT ILLINOIS

Robert Traub, a graduate of the College of the City of New York, with a master's degree from Cornell University, has been appointed as Assistant in the Department of Entomology at the University of Illinois. He has previously served as Assistant in Entomology at Cornell University, as Instructor in Biology in the College of the City of New York and has had experience in the American Museum of Natural History. Mr. Traub expects to conduct research on the Siphonaptera.

HORTICULTURAL INSPECTION NOTES

THE Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, has announced the revocation of the Woodgate rust quarantine, which since 1928 has prohibited the interstate movement of Scotch pines and other hard pines from an area in northern New York. Observations of the past several years have shown, the notice states, that the rust does not spread aggressively, and the disease is not believed to constitute a sufficiently serious menace to warrant the continuation of the quarantine. The revocation was made effective July 31, 1939.

CERTIFICATION requirements for specified articles consigned from certain parts of the areas regulated under the white-fringed beetle quarantine were lifted until February 1, 1940, by the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, through revisions of circular B.E.P.Q. 485 on July 7 and again on July 28, 1939. It has been determined that sanitary measures and natural conditions have so reduced the risk of contamination with the egg or adult stage of the beetle as to render certification unnecessary during the period stated.

Two important foreign plant quarantine conferences were held in June, 1939, one at New Orleans on June 8–10 to discuss maritime foreign plant quarantine problems in the Gulf States, and one at El Paso on June 16–17 to consider foreign plant quarantine problems on the Mexican border. The first conference was attended by inspectors from Brownsville, Galveston, Houston and Port Arthur, Tex., New Orleans, La., Mobile, Ala., Pensacola, Tampa, Key West, Miami, West Palm Beach, Jacksonville and Gainesville, Fla., Charleston, S. C., San Francisco, Calif., and Washington, D. C. The second was attended by district leaders from Brownsville, Laredo and El Paso, Tex., Nogales, Ariz., and San Francisco, Calif.

THE registration fee of $10.00 previously required of all out-of-state nurserymen in shipping to Virginia was abolished effective September 1. All shipments to that state must, however, continue to be accompanied by the Virginia tag.

LAWS of the state of Maine relating to the protection of trees and shrubs as amended in 1939 define nursery stock as "all florist stock, trees, shrubs, vines, fruiting plants, cuttings, grafts, scions and buds, both deciduous and evergreen, grown for sale or propagation, also herbaceous perennials, bedding plants, roots, corms, bulbs, tubers, potted plants and cut flowers, and all other plant and plant products for, or capable of, propagation, excepting field crops, vegetable plants, and vegetable and flower seeds."

THE Missouri quarantine relating to the phony peach disease, which was revised effective June 15, 1939, conforms both in area and nature of restrictions, to standardized quarantines with respect to this disease.

KUDZU plants or crowns shipped into Alabama, or within the state, must be accompanied by a special certificate for which a registration fee of $1.00 is required under regulation 5 of the Alabama Department of Agriculture and Industries. This regulation became effective June 23, 1939.

RECENT visitors at the Washington offices of the Bureau of Entomology and Plant Quarantine, U. S., Department of Agriculture, were H. A. U. Monro Supervising Inspector in charge of the Fumigation and Inspection Station of the Canadian Department of Agriculture at Montreal, who was studying methods of fumigation as applied to plants and plant products as a condition of entry, Mr. Luis A. Catoni, inspector in charge of the Porto Rican Inspection Service, whose interest was the inspection and treatment procedures as applying to plants and plant products.

TRANSPORTATION into Arkansas of vetch seed grown in states in which the vetch weevil is known to occur will hereafter be prohibited unless an official tag showing that the seed has been fumigated is sealed to each bag, according to a notice dated August 25, 1939, from the Arkansas State Plant Board. Vetch from states in which the weevil has not been found need not be fumigated but there must be sealed to each bag an official tag showing that it was grown in a weevil-free state, the notice further states.

W. W. WOOD, who had 14 years of experience in foreign plant quarantine work and who for the past year had been in charge of that work at the port of Seattle, Wash., passed away on April 21, 1939. Mr. Wood was succeeded by Louis M. Scott.

PROCEEDINGS OF THE FOURTEENTH ANNUAL MEETING

COTTON STATES BRANCH, AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Hillsboro Hotel, Tampa, Florida, February 20–23, 1939

The Fourteenth Annual Meeting of the Cotton States Branch of The American Association of Economic Entomologists was held in Tampa, Fla. on February 20, 21, 22 and 23, 1939. This meeting was held in conjunction with the Fourth Annual Florida Entomological Conference which is sponsored by the Newell Entomological Society of the University of Florida. The official hosts for the meeting were the Florida Entomological Society and the Newell Entomological Society. The attendance was the greatest in the history of the branch; 166 signed the attendance record.

On Monday evening, February 20, an informal smoker was held for the men in the Arbor Room of the Hillsboro Hotel, while a bridge party was given for visiting ladies on the mezzanine. The latter function was given in honor of Mrs. Wilmon Newell, wife of the Provost of Agriculture of the University of Florida. Other entertainment features provided for visiting ladies were a Florida West Coast motorcade tour, an informal bridge party, a tea given by the University of Tampa Women's Club, a motorcade tour of Tampa and special races at the Sulphur Springs race track.

The annual banquet was in the nature of a dinner dance and was held in the Columbia Restaurant of Ybor City on Tuesday evening, February 21. An elaborate floor show was presented. This was sponsored by the Florida Institute of Agricultural Research. Frank L. Holland, manager of this Institute, was master of ceremonies.

Wednesday was devoted to a bus tour of the Central Florida Citrus Section; 100 persons attended. The members of the tour visited the Florence Villa Packing House, Cypress Gardens, Bok Tower and The Citrus Experiment Station. Arthur F. Camp and John T. Creighton were in charge of the tour. At the Citrus Experiment Station the entomologists of this station presented a 3-hour spray demonstration dealing with the control of citrus pests. W. L. Thompson was in charge of this feature.

The chairman, Dr. C. O. Eddy of the Louisiana Experiment Station did not present his scheduled paper on "The Relation of Entomology to Southern Agriculture," but forcibly discussed a matter of immediate importance to the Cotton States Branch. This concerned the selection of the place for annual meetings.

Following this presentation a motion was made that the 1940 meeting of the Cotton States Branch be held in conjunction with the annual meetings of the Association of Southern Agricultural Workers, but that detailed discussions of this matter be deferred until next year. This motion was favorably acted upon by the membership.

A motion was then made that a business session be held annually near the middle of the program and that the executive committee be authorized to select the most suitable time. This likewise was favorably received by those present.

President E. R. Sasscer of the parent organization contributed a great deal to success of the annual meetings. He brought greetings and presided over one session. Mr. Sasscer attended many of the sessions and took part in a radio broadcast over station WDAE. Others taking a part in this broadcast were Dr. Dr. Lee A Strong and Dr. J. H. Montgomery.

The Citrus Symposium on Tuesday afternoon, February 21, was one of the highlights of this year's convention. J. R. Watson of the Florida Experiment Station served as leader. Discussions dealt with problems involved in the use of insecticides, cultural practices and their influence upon citrus insects, and the natural and biological control of citrus pests.

A total of 57 papers was presented. These included treatises on pests of cotton, citrus, peach, grain crops, peanuts, livestock, sugar cane, corn, gladiolus, soy

bean, forest products, pepper, sweet potato and household pests.

Two papers that attracted widespread interest were given by Dr. Wilmon Newell, Commissioner of the Florida State Plant Board, and Dr. Lee A Strong, Chief of The Bureau of Entomology and Plant Quarantine. The former dealt with the apparent successful eradication of blackfly from the Island of Key West, Florida. The latter treated the present status of the pink bollworm of cotton.

The membership accepted and indorsed a set of resolutions relative to the future control and quarantine activities which are to be directed at this cotton pest. The resolutions were as follows:

WHEREAS, The pink bollworm of cotton is now known to exist in the states of Texas, Arizona, New Mexico and Florida, and

WHEREAS, This insect is known to exist in Mexico and this infestation serves as a constant threat of reintroduction into certain areas in the United States where the insect has been previously eradicated, and

WHEREAS, This insect is considered to be the most destructive insect attacking cotton, and

WHEREAS, There are no known insecticides that will control this insect, and

WHEREAS, This insect is apparently now getting out of control and threatens to invade and establish itself in the main cotton belt of the United States with the known results that it will mean practically the elimination of the profitable production of cotton, and

WHEREAS, It has been demonstrated that the pink bollworm can be eradicated by restrictive or regulatory practices for the reason that this insect has been eradicated by using such measures in portions of the states of Texas, New Mexico, Arizona, Louisiana, Georgia and Florida, therefore be it

Resolved, By the Cotton States Branch of the American Association of Economic Entomologists, the membership of which is made up of entomologists of every major cotton growing state in the United States, in a regular meeting in Tampa, Florida, on February 3, 1939, that the members of the Branch urge Congress to authorize the U. S. Department of Agriculture to work with the Mexican government to determine if it is feasible to eradicate the pink bollworm from the North American continent and if so to work out a ways and means to carry out such a program and the financing of such a program. Be it further

Resolved, Pending such negotiations with Mexico, that Congress be urged to appropriate sufficient funds to hold this pest in check in Southern Texas to meet the serious emergency now existing there. Be it further

Resolved, That each member of the Cotton States Branch of the American Association of Economic Entomologists write each member of his respective Congressional delegation urging the above mentioned action, and that the Secretary of the Cotton States Branch be instructed to send a copy to Honorable Henry A. Wallace, Secretary of Agriculture, Dr. Lee A. Strong, Chief, Bureau of Entomology and Plant Quarantine, U. S Department of Agriculture, to each member of the Cotton States Branch of the American Association of Economic Entomologists, and to the Secretaries or Commissioners of Agriculture of each of the major cotton growing states.

Dr. W. S. Blatchley of Indiana and Florida was presented on Tuesday morning and gave an interesting discussion of his experiences as an entomologist. He was presented by Franklin Sherman.

BUSINESS PROCEEDINGS

The first business session was called to order at 9:12 a.m., Tuesday, February 21. Dr. C. O. Eddy, Chairman, was presiding. The following were present:

M. L. Anderson
P. N. Annand
F. S. Arant
C. A. Bass
E. W. Berger
J. A. Berly
J. L. Bigham
G. L. Bond
Edwin Booth
G. H. Bradley
K. E. Bragdon
K. P. Bragdon
M. R. Brown
W. G. Bruce
E. K. Bynum
O. L. Cartwright
F. S. Chamberlin
H. S. Chubb
J. C. Clark
S. W. Clark
R. P. Colmer
J. T. Creighton
W. P. Dean
Wallace Dekle
G. V. Dillard
E. W. Dunnam
C. O. Eddy
L. L. English
G. B. Fehmerling
Alfred Fenton
L. C. Fife
W. S. Fletcher
John Frederick
B. R. Fudge
A. L. Galloway
P. M. Gilmer
J. H. Girardeau
P. A. Glick
J. C. Goodwin
A. L. Hamner
R. W. Harned
J. S. Haeger
Roy Haufler
Homer Hixson

J. K. Holloway
N. F. Howard
W. P. Hunter
J. W. Ingram
M. J. Jones
M. P. Jones
W. L. Kersey
W. V. King
J. P. Kislanko
Tommy Kloos
R. A. Knight
W. W. Lawless
J. E. Lee
Clay Lyle
T. E. McNeel
W. D. Mankin
J. E. Maxwell
H. Mayfield
W. H. Mecom
Jack Melton
G. B. Merrill
Z. P. Metcalf
R. L. Miller
J. H. Montgomery
Milledge Murphy
W. C. Nanney
G. P. Naquin
W. C. Nettles
Wilmon Newell
M. R. Osburn
C. M. Packard
L. J. Padgett
Arthur Pasternak
N. D. Peets
P. D. Peterson
A. M. Phillips
R. D. Potter
C. F. Rainwater
R. T. Rawlings
Richard Remington
G. D. Reynolds
R. G. Richmond
C. S. Rude
J. C. Russell
E. R. Sasscer
F. Sherman
O. I. Snapp
J. K. Sparkman
H. Spencer
J. R. Springer
C. F. Stahl
Walter Stirling
H. L. Sweetman
M. C. Swingle
D. J. Taylor
J. N. Tenhet
A. N. Tissot
W. L. Thompson
H. A. Thullberry
J. N. Todd
J. P. Toffaleti
B. V. Travis
Joseph Tremble
M. C. Van Horn
Harold Waters
J. R. Watson
J. S. Whittington
J. W. Wilson
C. B. Wisecup
M. S. Yeomans
W. W. Yothers
H. C. Young
L. V. Ziegler
Tillman Zeigler

Chairman Eddy called for a report of the Secretary-Treasurer. The report was as follows:

REPORT OF THE SECRETARY-TREASURER

The number of members in the Cotton States Branch on December 31, 1938, was 191. There was a net increase of four members during the year, after removing the names of those who moved out of the Branch territory or were dropped by the parent Association. The membership has shown a yearly increase since the period 1930–35 which was one of gradual decrease.

The number of members by states on December 31, 1938, was as follows: Texas, 47; Florida, 31; Louisiana, 30; Mississippi, 21; Georgia, 14; North Carolina, 12; South Carolina, 12; Alabama, 8; Arkansas, 6; Oklahoma, 5; and Tennessee, 5. The following states showed a net increase during the year: Florida, 5; Louisiana, 4; Mississippi, 2; Oklahoma, 2; Alabama, 1. Net decreases during the year were as follows: Texas, 5; Georgia, 3; and Tennessee, 2. There was no change in the number of members in the states of North Carolina, South Carolina and Arkansas during the year. There are several hundred entomological workers in the 11 Cotton States who are still not members of the American Association of Economic Entomologists, and members of the Branch should encourage these men to file application for membership in the parent Association. Lists of these workers will be gladly furnished upon application to the Secretary of the Cotton States Branch.

On January 6, 1939, the Secretary sent to each member of the Branch an invitation to participate in the regular annual meeting in Tampa, Fla., on February 21–23, 1939. The program for that meeting was mailed to each member on February 10, 1939. A letter of greetings and felicitations from the Branch and a special invitation to attend the Tampa meetings was sent to the Texas Entomological Society in annual session at Dallas, Tex., February 9–11, 1939. The proceedings of the thirteenth annual (New Orleans, La.) meeting of the Cotton States Branch were published in the December, 1938 (Vol. 31, No. 6) issue of the JOURNAL OF ECONOMIC ENTOMOLOGY, and a report on the twelfth annual (San Antonio, Tex.) meeting was published in the February, 1938 (Vol. 31, No. 1) issue of that Journal. A report on the last annual meeting of the Branch was read by the Secretary at the Richmond meeting of the parent Association on December 28, 1938.

Annual dues in the Cotton States Branch are $1.00. Fifty-seven of the 191 members have paid dues for 1938, and only eight members have paid their 1939 dues which are now payable.

FINANCIAL STATEMENT, COTTON STATES BRANCH, AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS, FEBRUARY 3, 1938 TO FEBRUARY 20, 1939

Funds Received

1938

Feb. 3	Amount on hand	$162.89
Feb. 21	American Association of Economic Entomologists	27.52
	Contributions	33.00
	1933 annual dues from one member	1.00
	1934 annual dues from one member	1.00
	1935 annual dues from one member	1.00
	1936 annual dues from two members	2.00
	1937 annual dues from 4 members	4.00
	1938 annual dues from 53 members	53.00

1939

Jan. 1	Interest on deposit in Savings Department of First National Bank, Atlanta, Ga., from January 1, 1938 to December 31, 1938	1.70
	Contributions	6.00
	1938 annual dues from 8 members	8.00
	Amount received during year	$301.11

Funds Expended

1938

Feb. 10	Harcol Motion Picture Industries, Inc.	$ 5.00
Feb. 11	Expense incurred at the 1938 (New Orleans, La.) meeting. (By order of the Executive Committee)	66.60
Feb. 11	Fifty 3-cent stamped envelopes	1.63
Feb. 16	Postage for mailing proceedings and papers to Editor of JOURNAL OF ECONOMIC ENTOMOLOGY	1.35
Nov. 14	Fifty 3-cent stamped envelopes	1.63

Dec.	14	Three hundred 1½-cent stamped envelopes for mailing notices of Tampa meeting	5.25
		1939	
Jan.	3	Fifty 3-cent stamped envelopes	1.63
Jan.	6	Golden Rule Press for printing 400 announcements of Tampa meeting	4.00
Jan.	18	Sommer Badge Mfg. Co. for 125 badges for Tampa meeting	8.92
Jan.	18	Fifty 3-cent stamped envelopes	1.63
Feb.	1	Fifty 3-cent stamped envelopes	1.63
Feb.	7	Three hundred 1½-cent stamped envelopes for mailing programs of Tampa meeting	5.25
Feb.	10	Golden Rule Press for printing 500 programs of Tampa meeting	17.50
Feb.	10	Fifty 3-cent stamped envelopes	1.63
		Amount spent during year. .	$123.65
		Amount on hand Feb. 21, 1939....	$178.46

Respectfully submitted,

OLIVER I. SNAPP,
Secretary-Treasurer
COTTON STATES BRANCH,
AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Fort Valley, Ga.
February 20, 1939

FINAL BUSINESS SESSION

Chairman C. O. Eddy called for the report of appointed committees.

The auditing committee reported that their examination of the financial report made by the Secretary-Treasurer revealed that it was accurate and correct. This report was accepted and a certificate presented to O. I. Snapp.

The publications committee requested that all authors forward their papers direct to Dr. T. H. Frison, Editor of the JOURNAL OF ECONOMIC ENTOMOLOGY, if said papers were not ready for submission before adjournment.

The following resolutions were presented and adopted:

The Resolutions Committee submits the following:

The Cotton States Branch of the American Association of Economic Entomologists having held its Fourteenth Annual Meeting at Tampa, Fla., February 21–23, 1939, expresses appreciation and thanks

(1) To Mr. E. R. Sasscer, President of the American Association of Economic Entomologists for his attendance and greetings of the parent Association.

(2) To the Newell Entomological Society and the Florida Entomological Society, our hosts, and their committee on arrangements, namely, John T. Creighton, W. V. King, J. H. Montgomery, R. L. Miller, W. W. Yothers, J. P. Toffaleti, W. P. Dean, Frank L. Holland and Wilmon Newell, for their efforts in making this meeting a success.

(3) To the Hillsboro Hotel for the excellent facilities for the general sessions and for committee rooms.

(4) To the press for favorable publicity.

(5) To the numerous firms and organizations who contributed materially to the host societies.

E. W. DUNNAM
O. L. CARTWRIGHT
M. V. KING

The nominations committee recommended the following for the year 1939–1940:

Oliver I. Snapp, Fort Valley, Ga., Chairman
L. L. English, Spring Hill, Ala., Vice Chairman
John T. Creighton, Gainesville, Fla., Secretary-Treasurer

A motion was made and seconded that nominations be closed and that the Secretary be instructed to cast a single ballot for the election of those men recommended by the nominations committee. This was favorably acted upon by the membership. The new Chairman, Mr. Snapp, took over the gavel at 3:15 p.m., and final adjournment was proclaimed shortly thereafter.

JOHN T. CREIGHTON
Secretary-Treasurer